UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Escola Tècnica Superior d'Enginyeries Industrial i Aeronàutica de Terrassa

Titulació:

Màster universitari en enginyeria de Sistemes Automàtics i Electrónica Industrial.

Alumne:

Sr. Pol Paradell Solà.

Títol TFM:

Disseny i muntatge d'un convertidor d'alta eficiència.

Director/a del TFM:

Dr. Jordi Zaragoza Bertomeu.

Convocatòria de lliurament del TFM:

Abril de 2016.

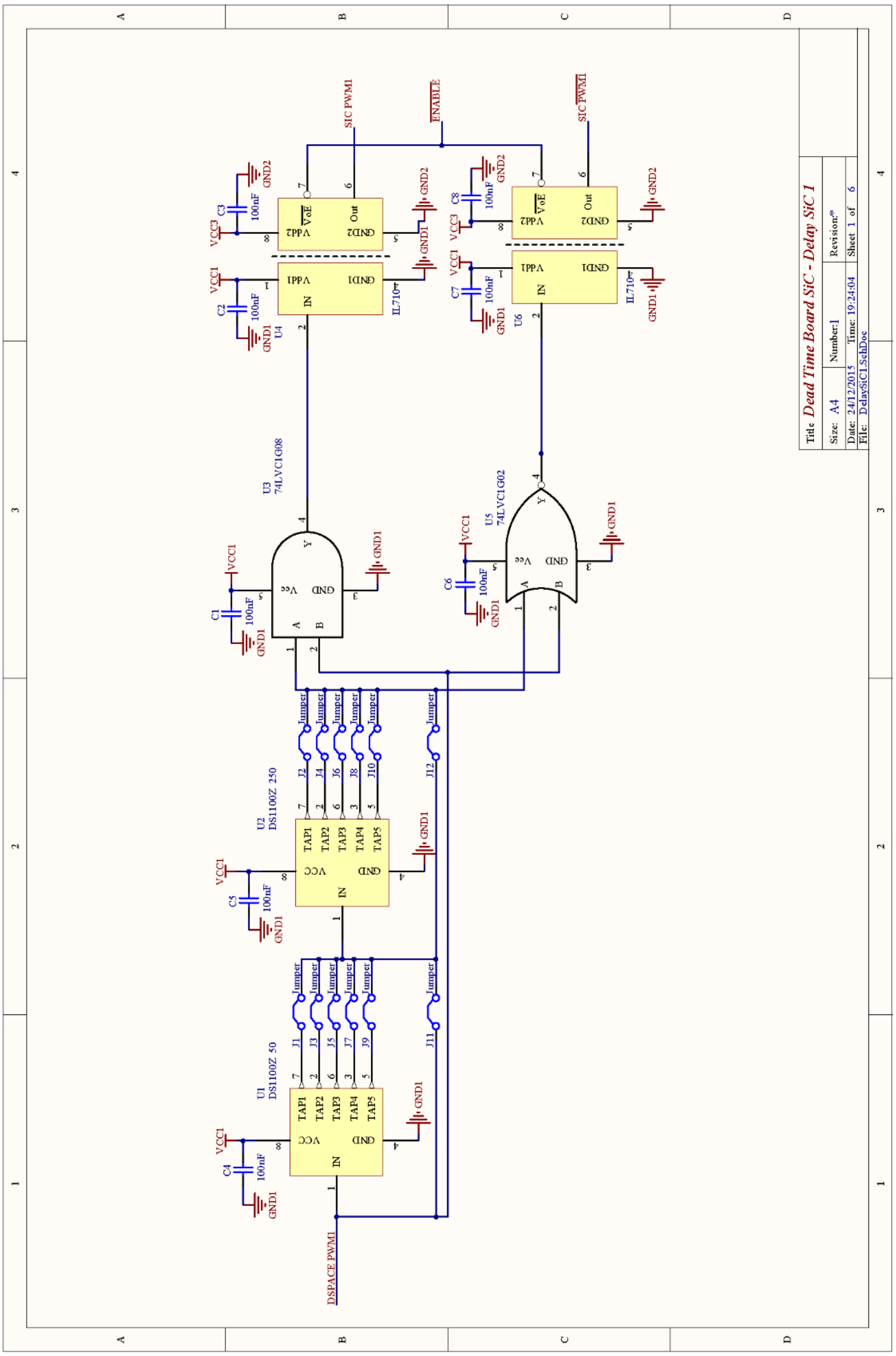
Contingut d'aquest volum:

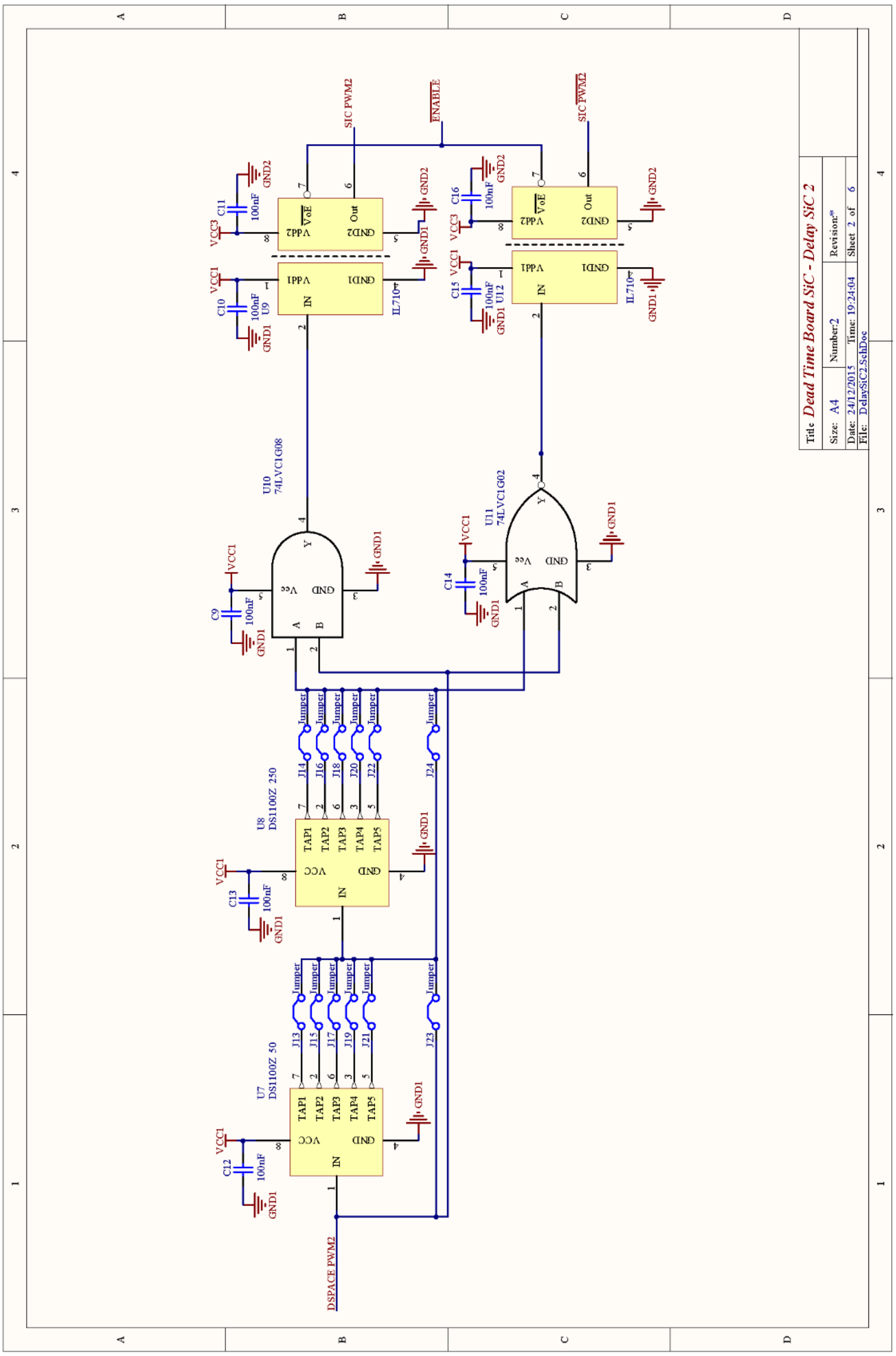
Annex

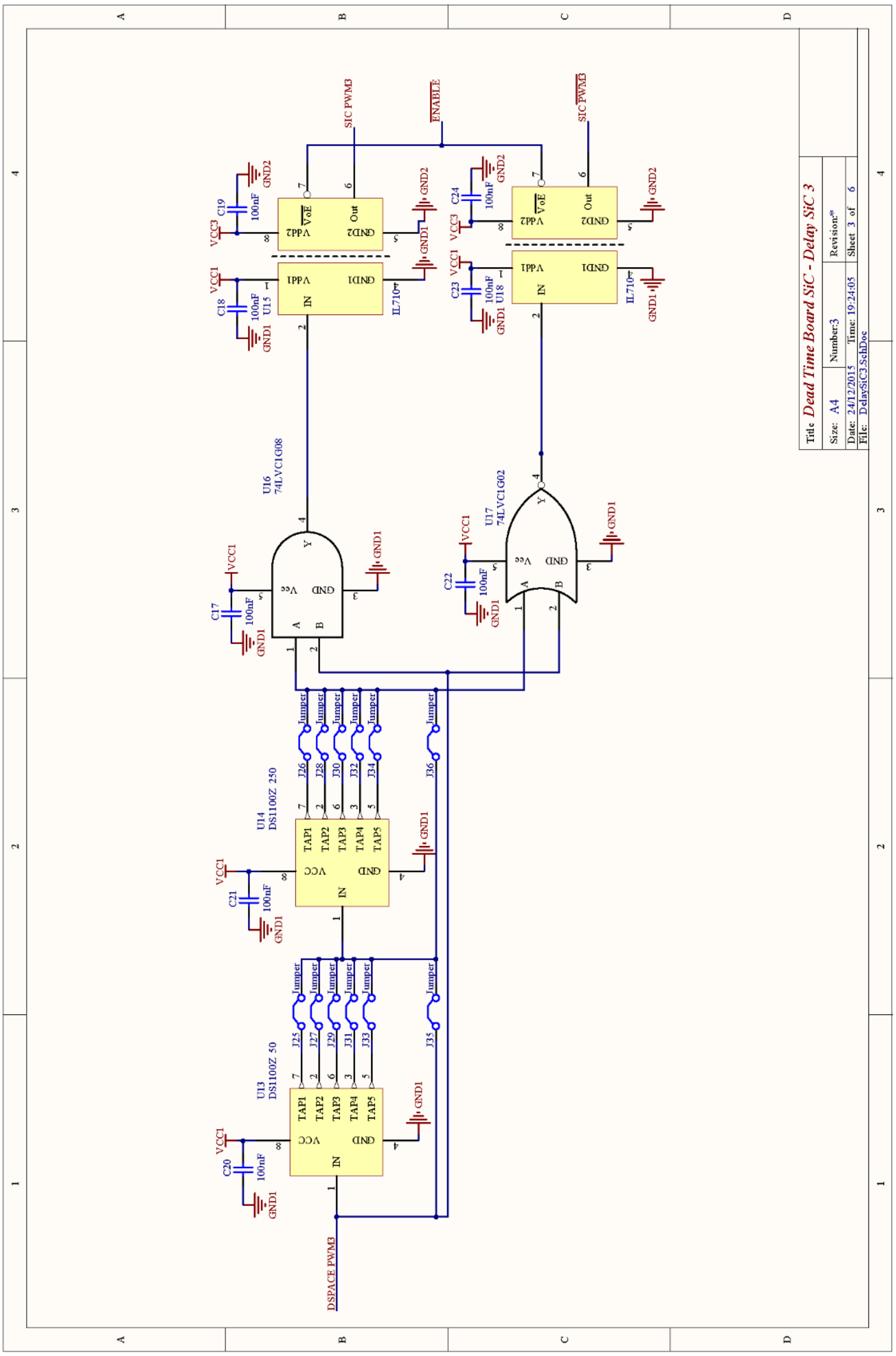
Índex de l'annex

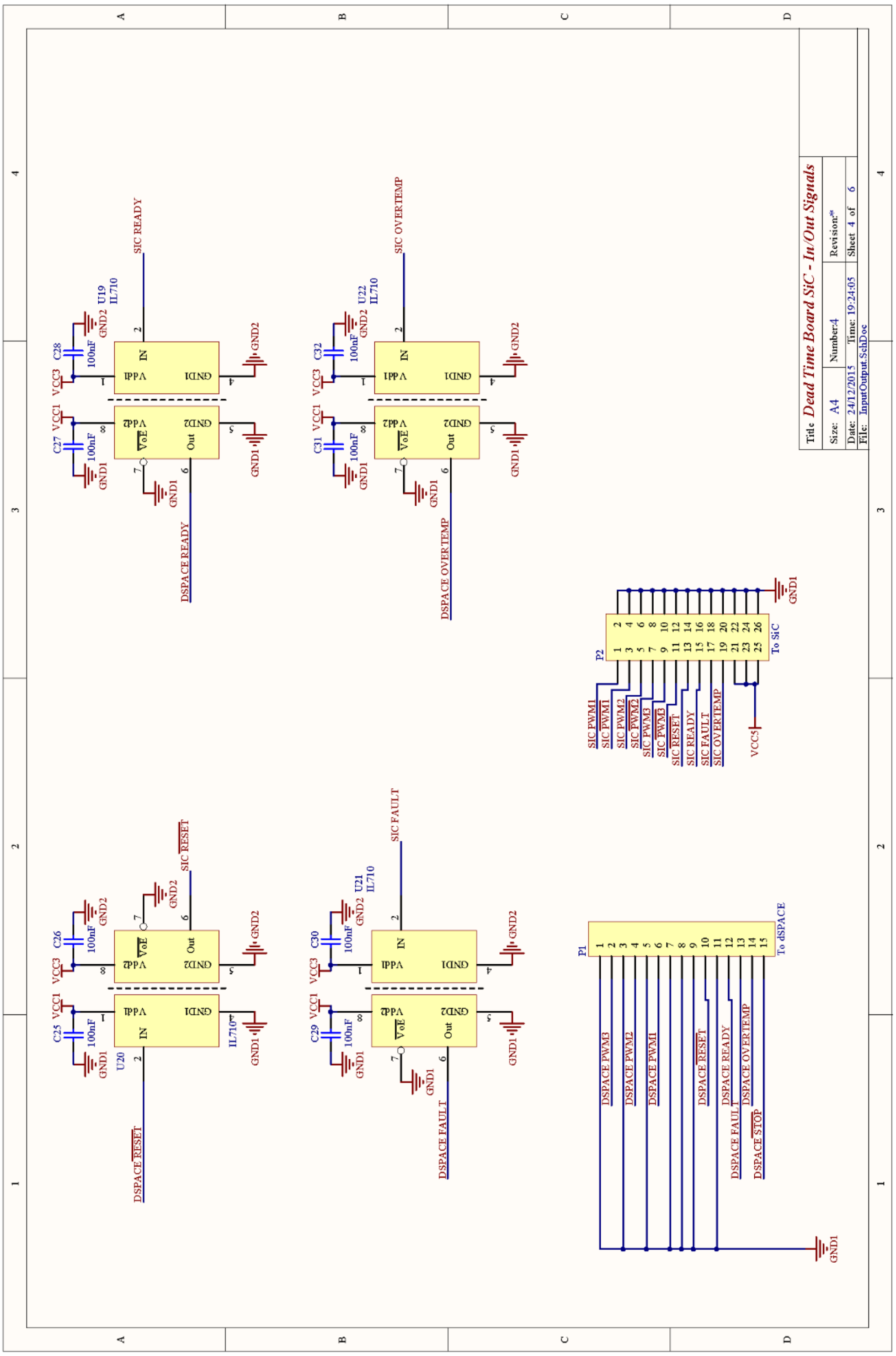
1 ESQUEMES ELÈCTRICS

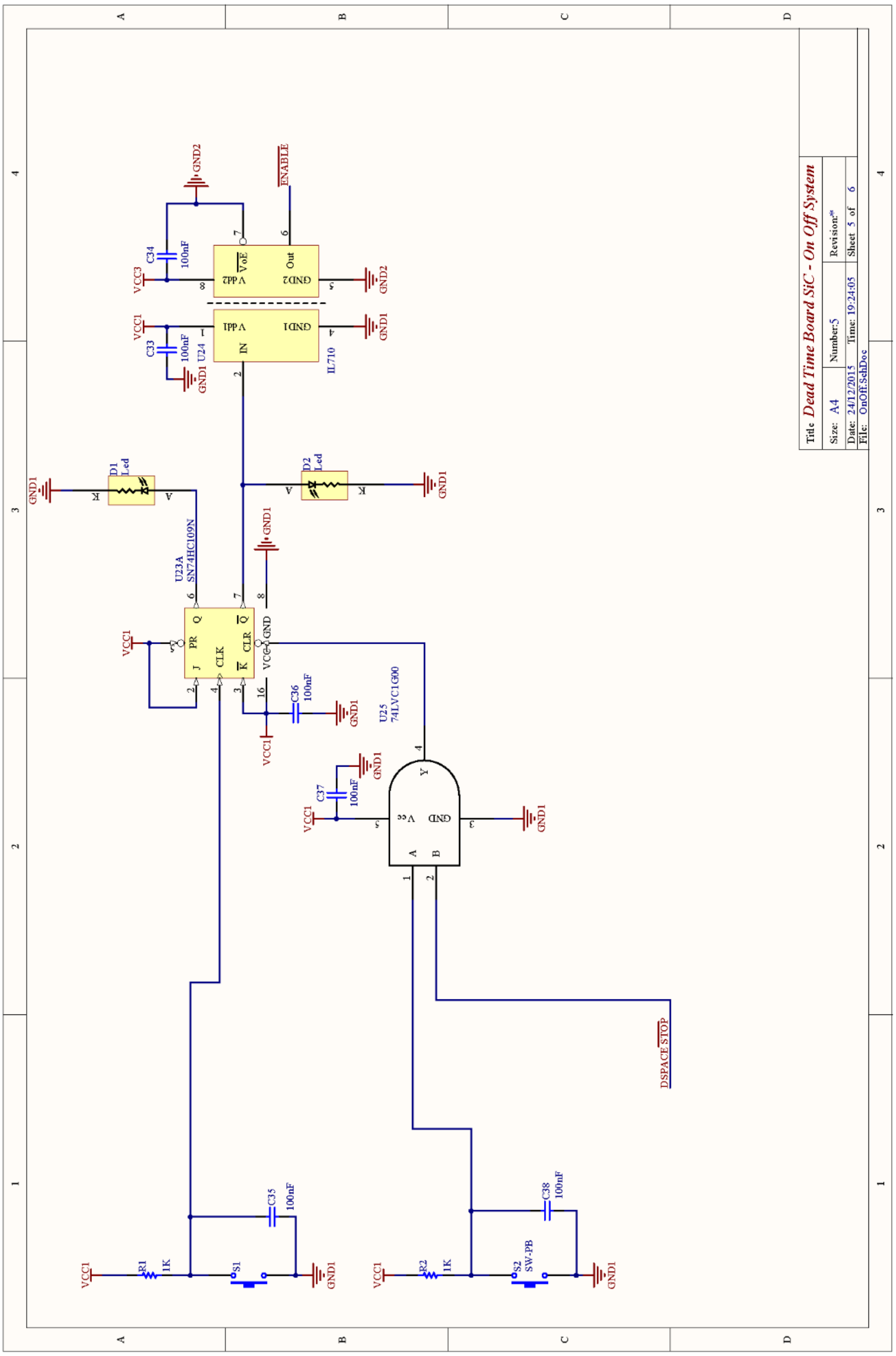
1.1 Placa temps morts

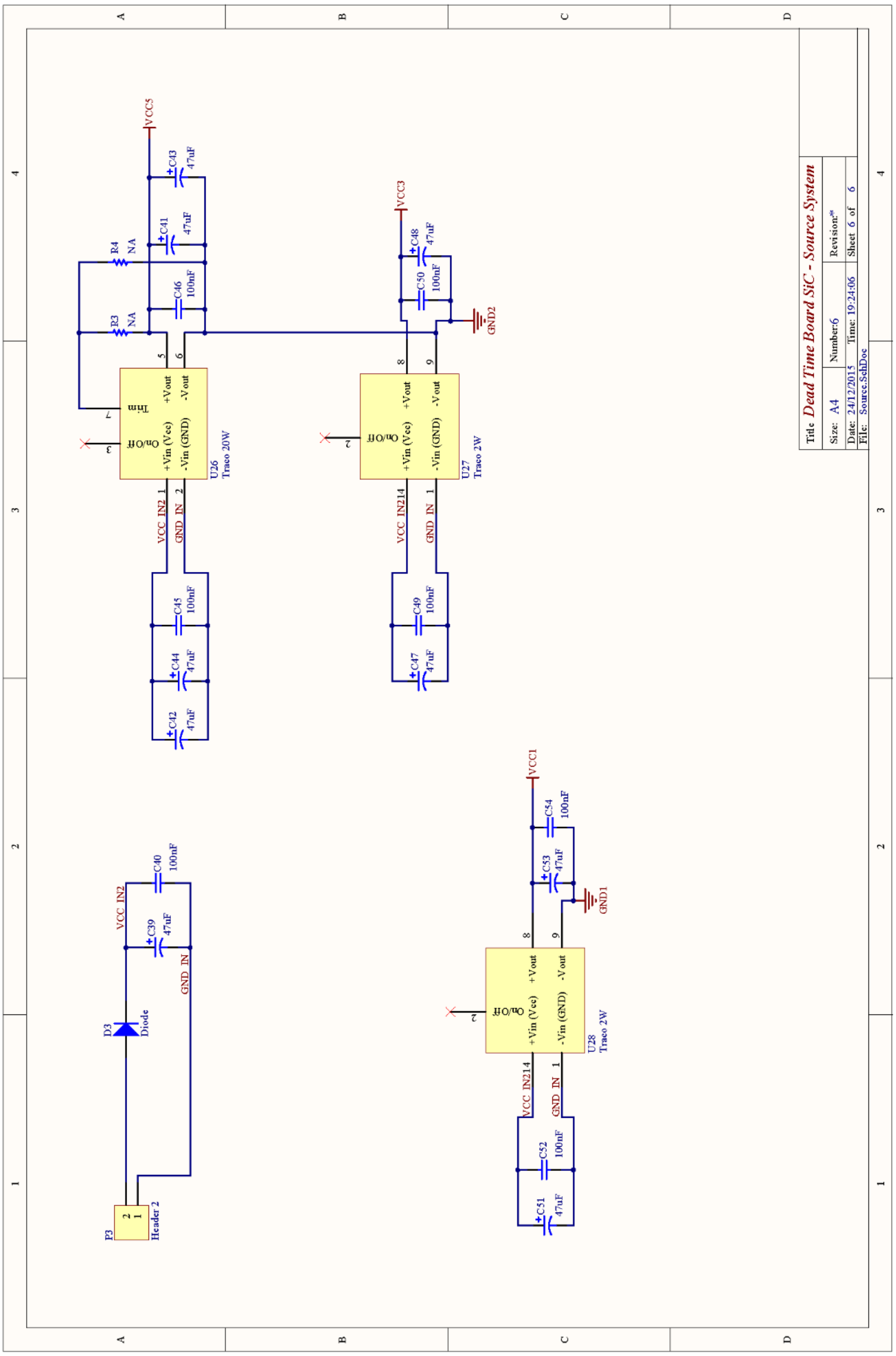



Title Dead Time Board SiC - Delay SiC 2
Size: A4
Number: 2
Date: 24/12/2015
Time: 19:24:04
Sheet 2 of 6
File: DelaySiC2.SchDoc
SIC PWM2
ENABLE
DSPACE PWM2
U7 DS1100Z 50
U8 DS1100Z 250
U10 74LVC1G08
U11 74LVC1G02
IL710

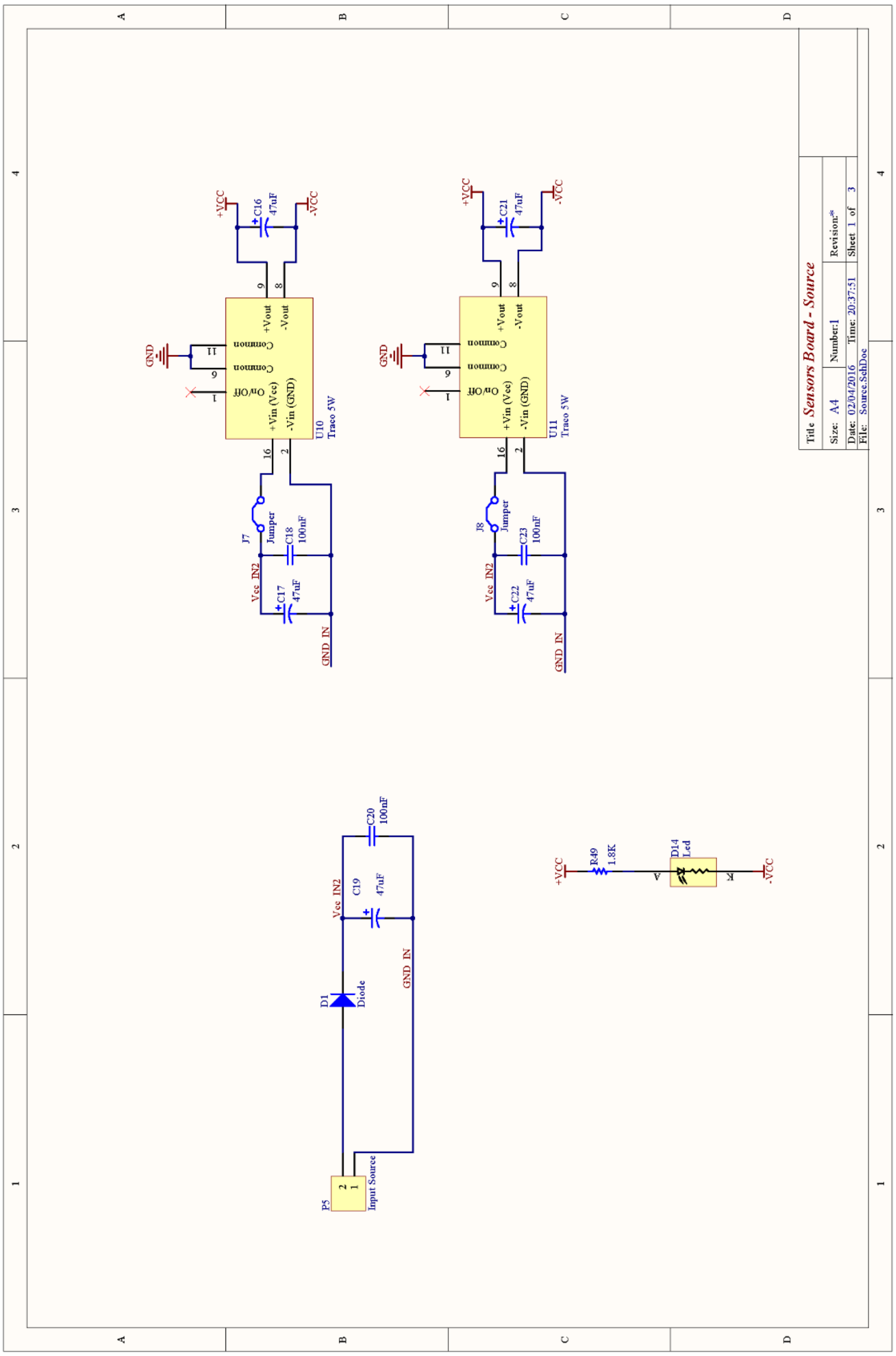

Title Dead Time Board SiC - Delay SiC 3
Size: A4
Number:3
Revision:
Date: 24/12/2015
Time: 19:24:05
Sheet 3 of 6
File: DelaySiC3.SchDoc
SIC PWM3
ENABLE
DSPACE PWM3
U13 DS1100Z 50
U14 DS1100Z 250
U15 IL710
U18 IL710
U16 74LVC1G08
U17 74LVC1G02

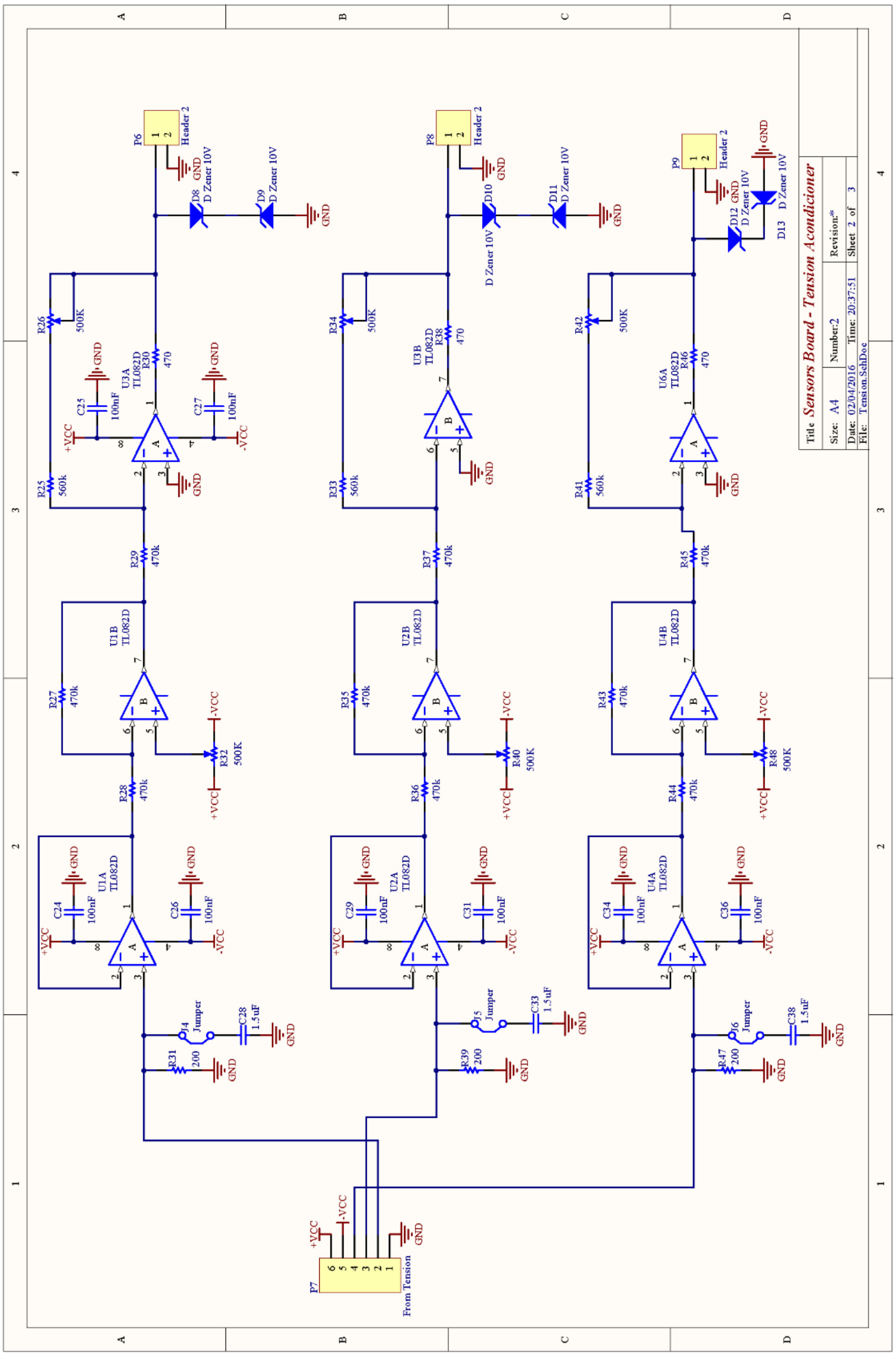

Title Dead Time Board SiC - In/Out Signals
Size: A4
Number:4
Date: 24/12/2015
Time: 19:24:05
Sheet 4 of 6
File: InputOutput.SchDoc
SIC READY
DSPACE READY
SIC OVERTEMP
DSPACE OVERTEMP
SIC RESET
DSPACE RESET
SIC FAULT
DSPACE FAULT
To SiC
To dSPACE
DSPACE STOP

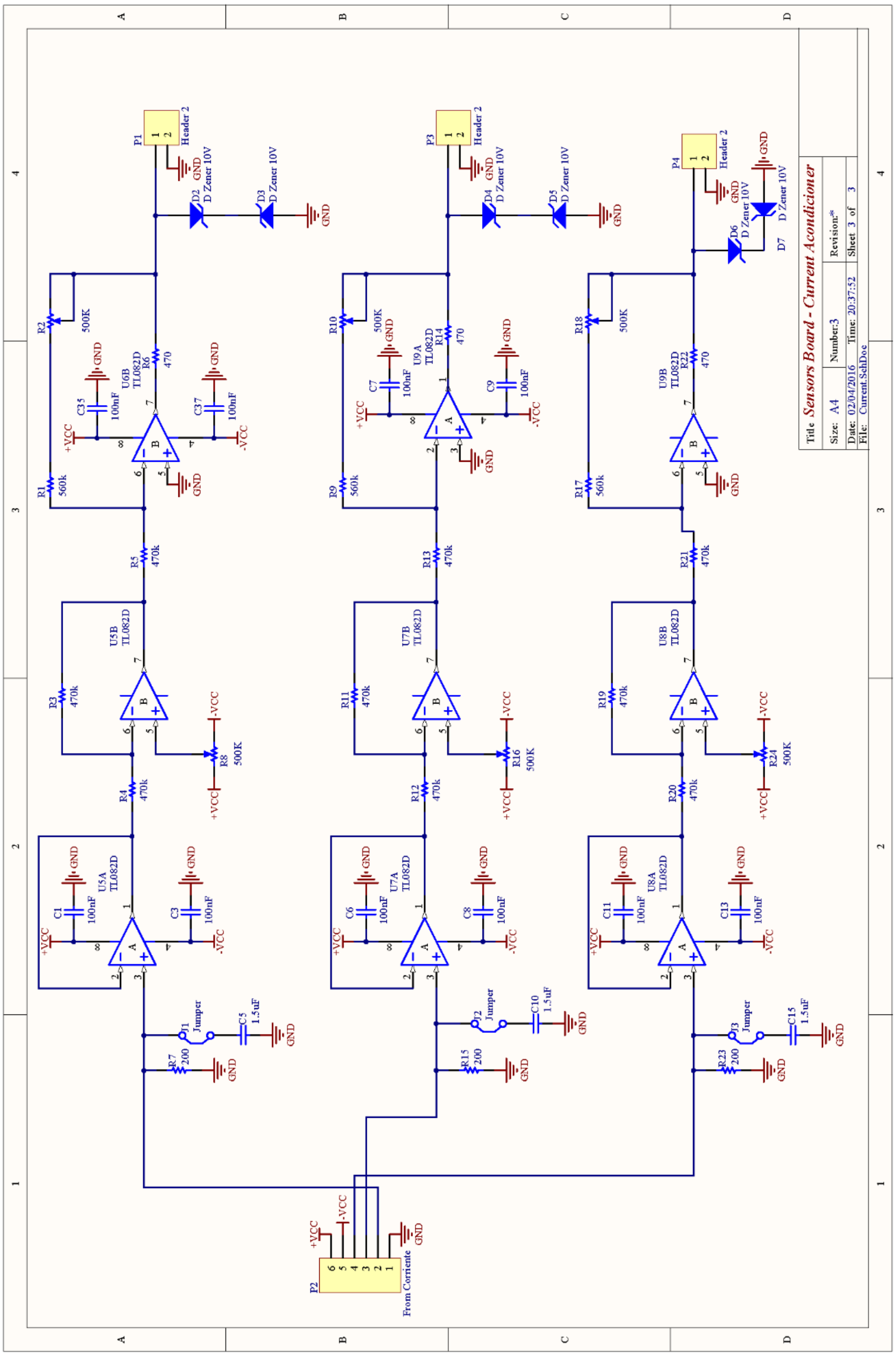

Title Dead Time Board SiC - On Off System
Size: A4
Number: 5
Date: 24/12/2015
Time: 19:24:05
Sheet 5 of 6
File: OnOff.SchDoc
U23A
SN74HC109N
U24
IL710
U25
74LV1G00
ENABLE
DSPACE STOP
D1 Led
D2 Led
R1 1K
R2 1K
S1
S2 SW-PB
C33 100nF
C34 100nF
C35 100nF
C36 100nF
C37 100nF
C38 100nF
VCC1
VCC3
GND1
GND2


Title Dead Time Board SiC - Source System
Size: A4
Number: 6
Revision:
Date: 24/12/2015
Time: 19:24:06
Sheet 6 of 6
File: Source.SchDoc
VCC5
VCC3
VCC1
GND2
GND1
VCC_IN2
GND_IN
VCC_IN214
U26
Traco 20W
U27
Traco 2W
U28
Traco 2W
+Vin (Vcc)
-Vin (GND)
+Vout
-Vout
On/Off
Trim
R3
R4
NA
C39
C40
C41
C42
C43
C44
C45
C46
C47
C48
C49
C50
C51
C52
C53
C54
47uF
100nF
D3
Diode
P3
Header 2

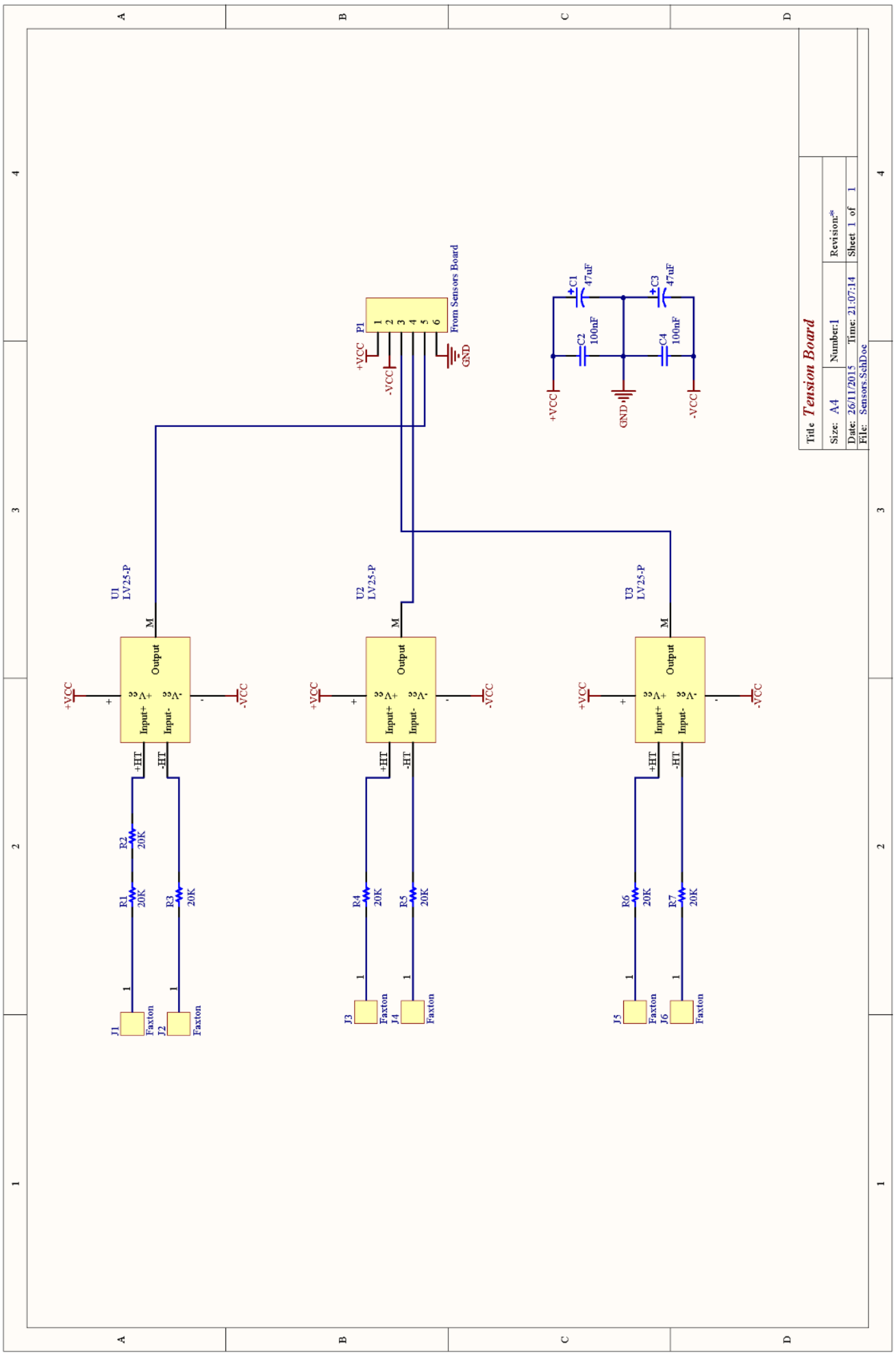
1.2 Placa de sensors



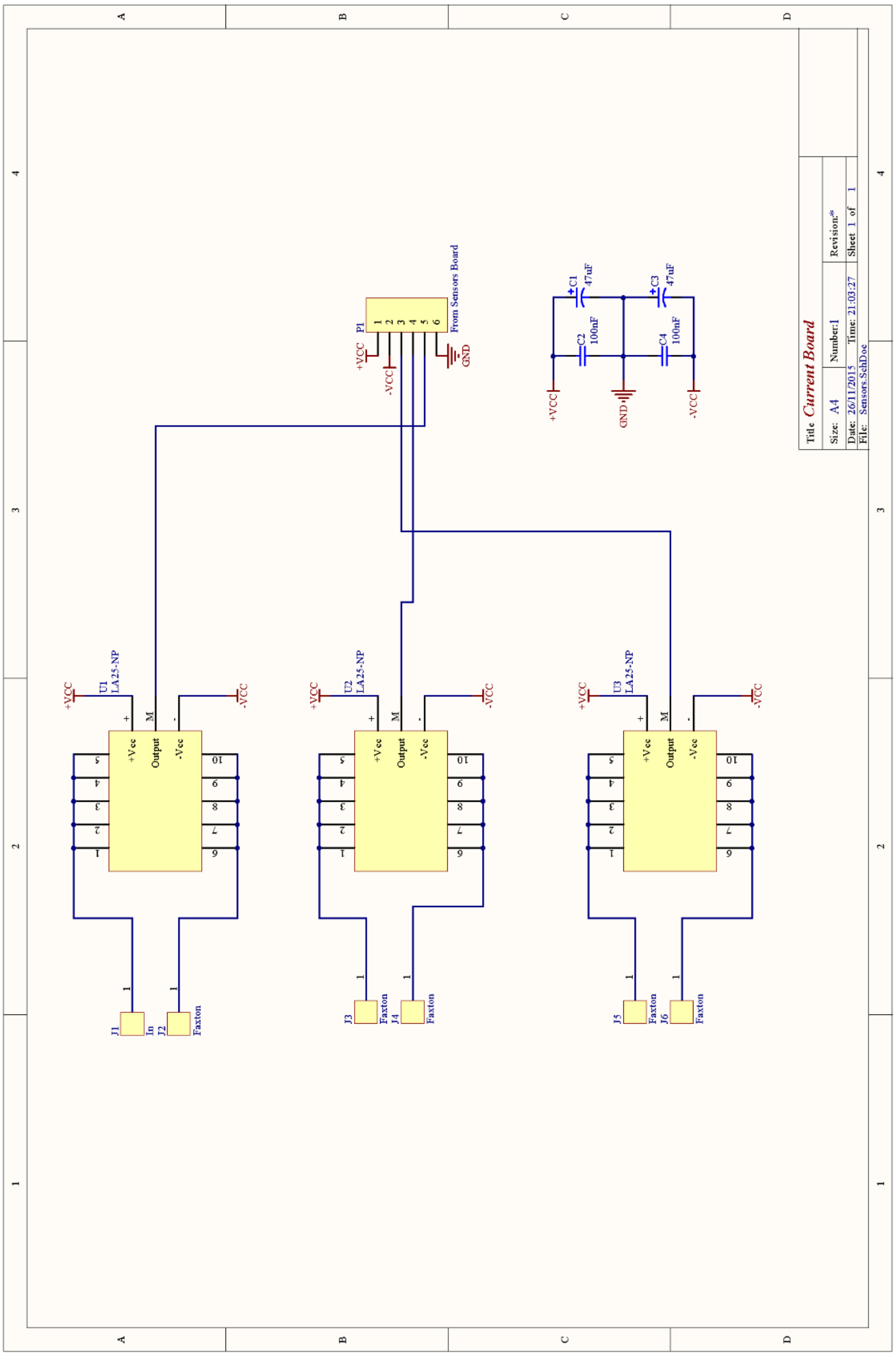



Title Sensors Board - Current Acondicioner
Size: A4
Number:3
Revision:*
Date: 02/04/2016
Time: 20:37:52
Sheet 3 of 3
File: Current.SchDoc
P1
Header 2
P3
Header 2
P4
Header 2
P2
From Corriente
D2 D Zener 10V
D3 D Zener 10V
D4 D Zener 10V
D5 D Zener 10V
D6 D Zener 10V
D7 D Zener 10V
U5A TL082D
U5B TL082D
U6B TL082D
U7A TL082D
U7B TL082D
U8A TL082D
U8B TL082D
U9A TL082D
U9B TL082D
R1 560k
R2 500K
R3 470k
R4 470k
R5 470k
R6 470
R7 200
R8 500K
R9 560k
R10 500K
R11 470k
R12 470k
R13 470k
R14 470
R15 200
R16 500K
R17 560k
R18 500K
R19 470k
R20 470k
R21 470k
R22 470
R23 200
R24 500K
C1 100nF
C3 100nF
C5 1.5uF
C6 100nF
C7 100nF
C8 100nF
C9 100nF
C10 1.5uF
C11 100nF
C13 100nF
C15 1.5uF
C35 100nF
C37 100nF
J1 Jumper
J2 Jumper
J3 Jumper
+VCC
-VCC
GND

1.3 Placa sensors de tensió

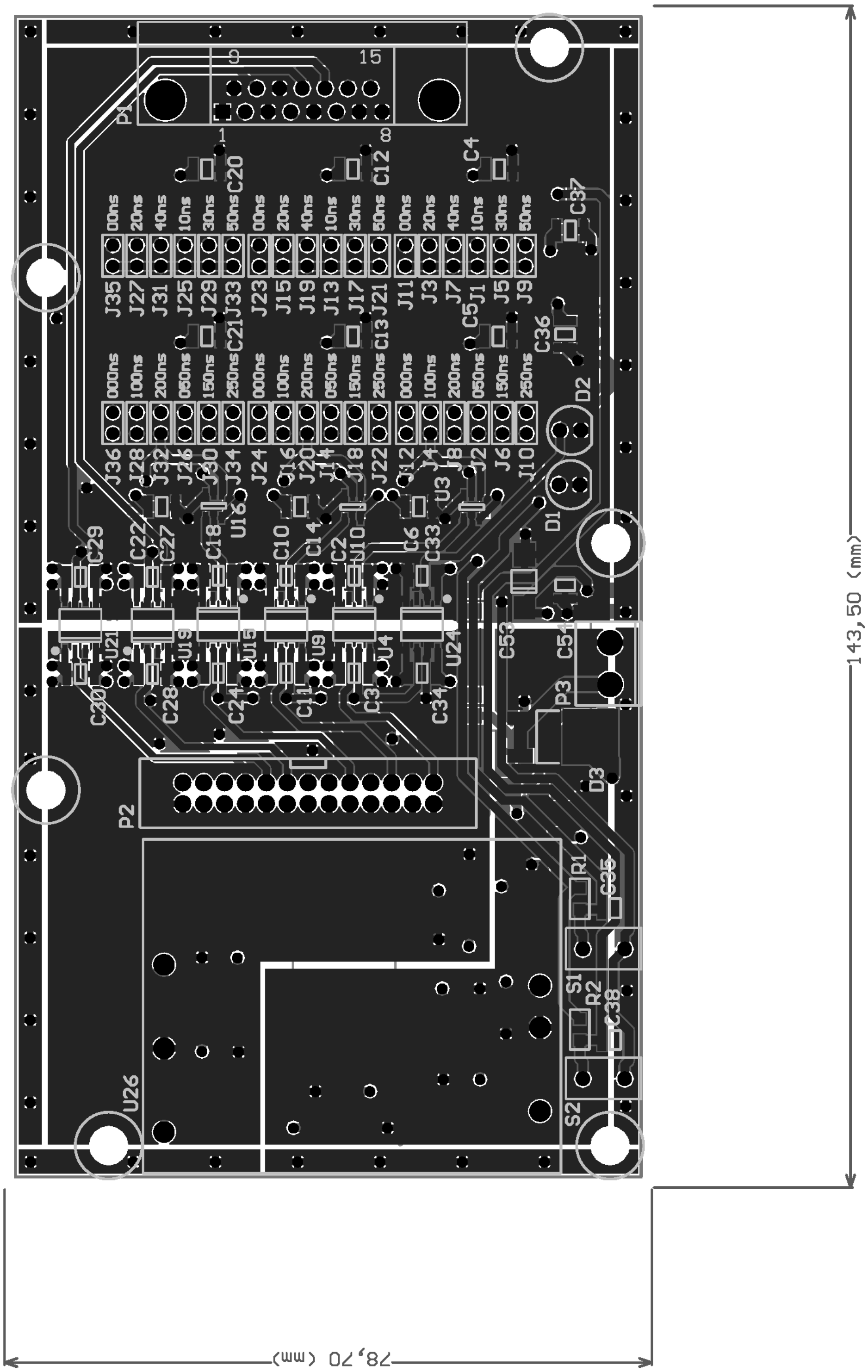


1.4 Placa dels sensors de corrent

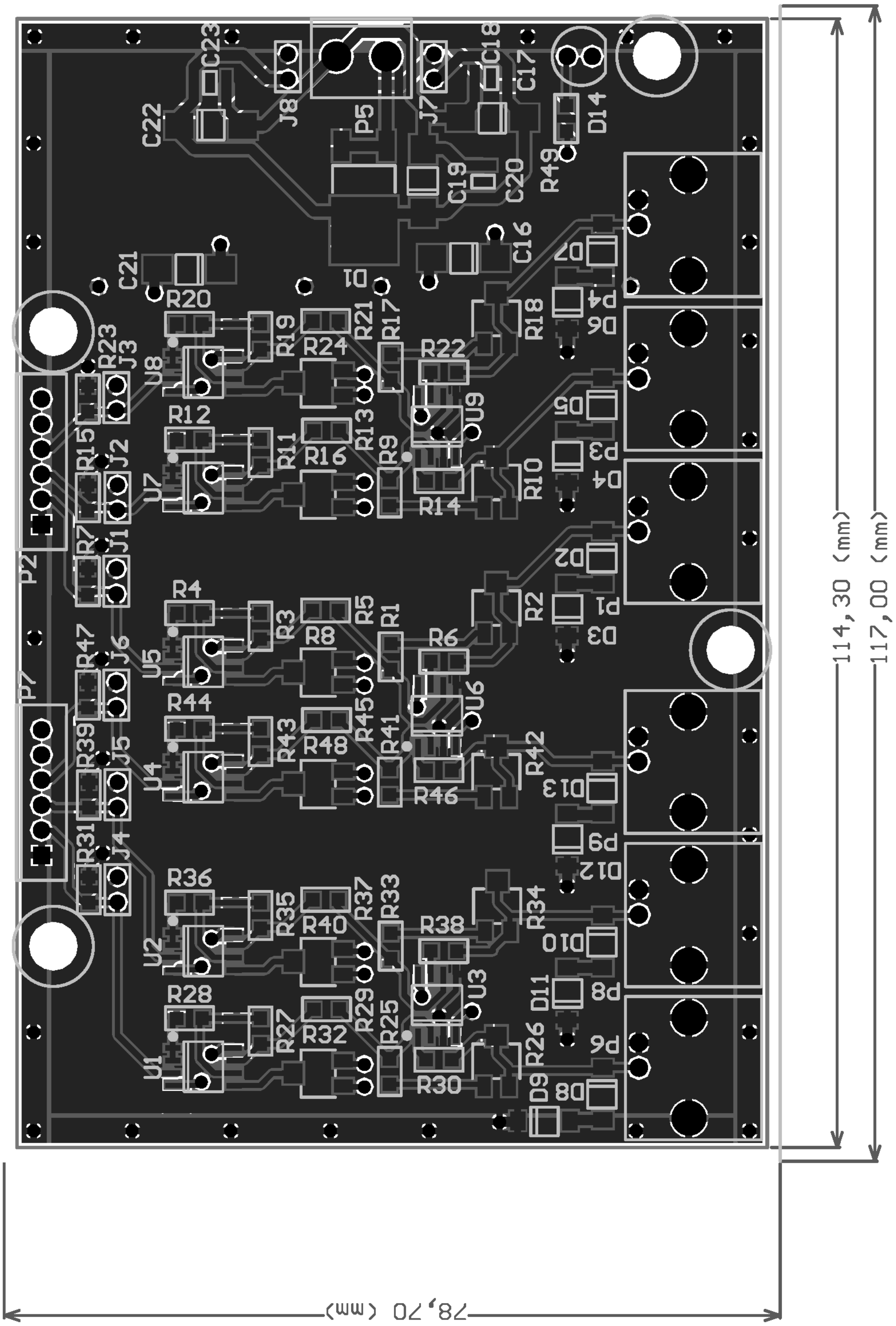


2 PLAQUES DE CIRCUIT IMPRÉS

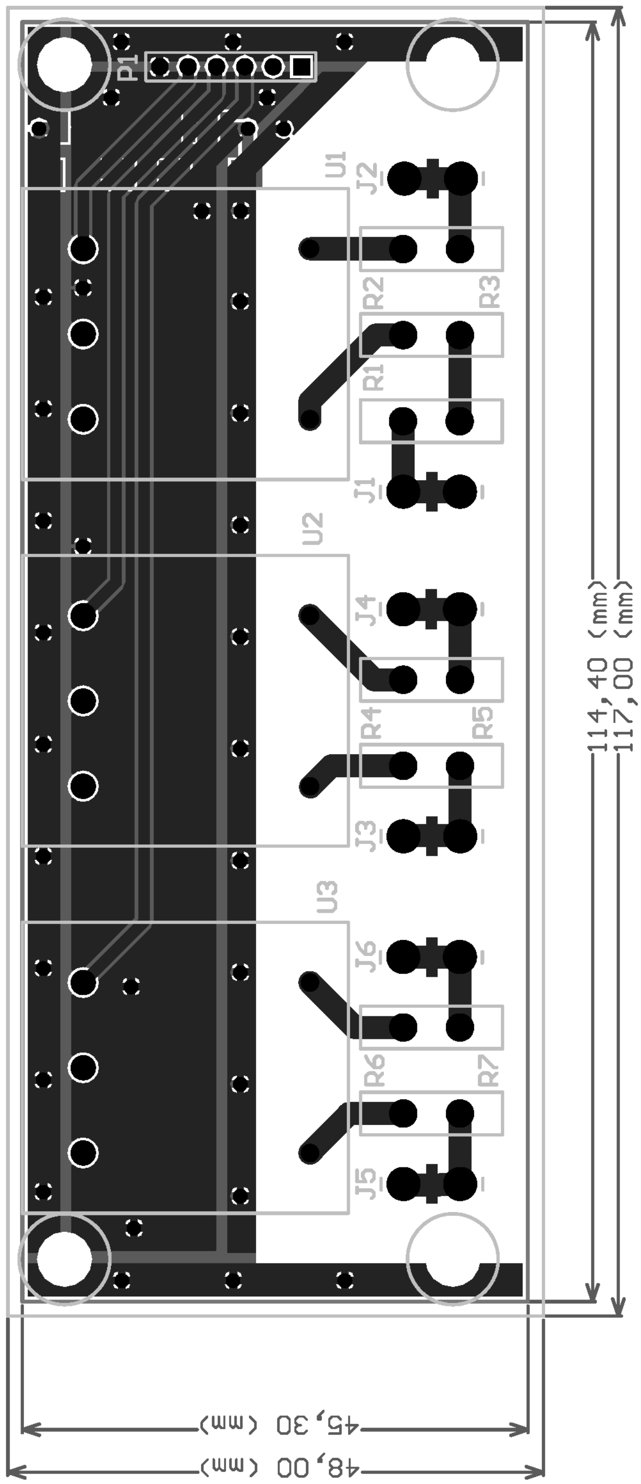
2.1 Placa temps morts



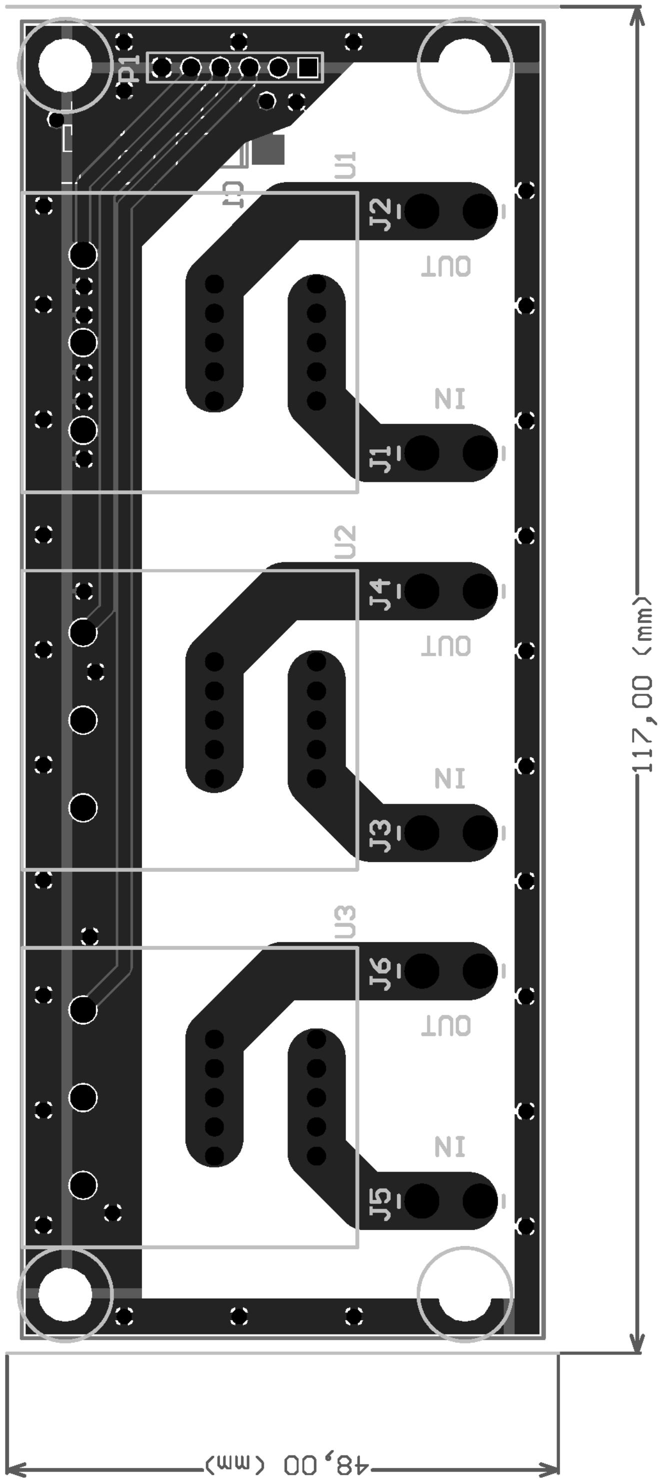
2.2 Placa de sensors



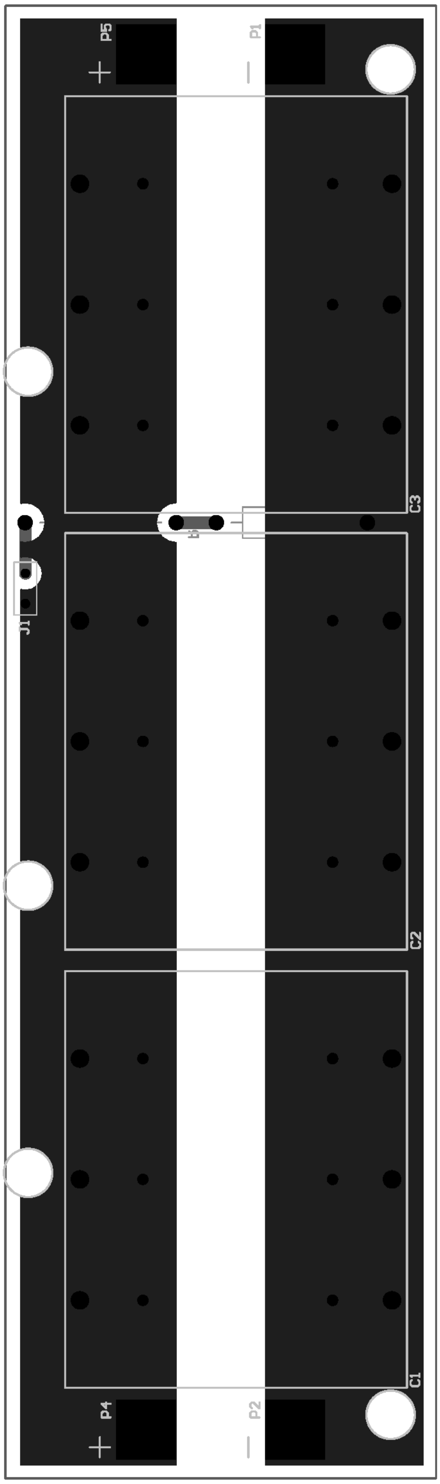
2.3 Placa sensors de tensió

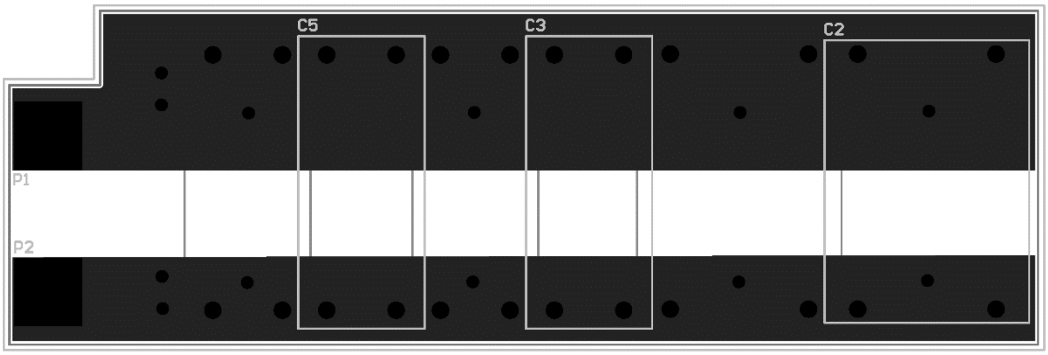


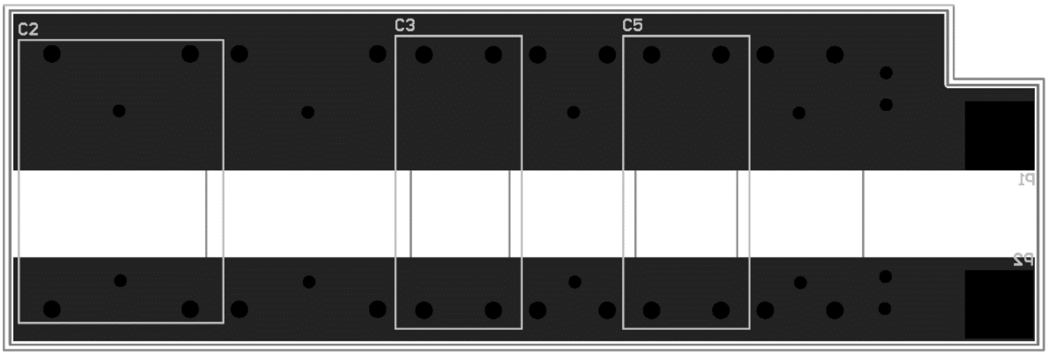
2.4 Placa dels sensors de corrent



2.5 Plaques del bus de continua




C5
C3
C2
P1
P2


C2
C3
C5

3 LLISTAT DE MATERIALS

3.1 Placa de temps morts

Part List — **Bill of Materials For PCB Document [PCBSiC2.PcbDoc]**

Source Data From: PCBSiC2.PcbDoc
Project: DeadBandSiC.PrjPcb
Variant: None

Report Date: 27/12/2015 12:35:17

Designator	Comment	Footprint	Description	Quantity
C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13, C14, C15, C16, C17, C18, C19, C20, C21, C22, C23, C24, C25, C26, C27, C28, C29, C30, C31, C32, C33, C34, C35, C36, C37, C38, C40, C45, C46, C49, C50, C52, C54	Cap	SMD Ceramic Capacitor	Capacitor 100nF	45,00
C39, C41, C42, C43, C44, C47, C48, C51, C53	Cap Pol1	SMD Pol. Capacitor	Polarized Capacitor 47uF	9,00
D1	Led	LED 5mm G	Diode led	1,00
D2	Led	LED 5mm R	Diode led	1,00
D3	Diode	TO 252	Default Diode	1,00
J1, J2, J3, J4, J5, J6, J7, J8, J9, J10, J11, J12, J13, J14, J15, J16, J17, J18, J19, J20, J21, J22, J23, J24, J25, J26, J27, J28, J29, J30, J31, J32, J33, J34, J35, J36	Jumper	Jumer 2	Jumper Wire	36,00
P1	Header 15	DSUB 15	Header, 15-Pin	1,00
P2	Header 13X2	IDC 26	Header, 13-Pin, Dual row	1,00
P3	Header 2	Terminal Connector 2	Header, 2-Pin	1,00
R1, R2, R3, R4	Res1	SMD Resistor 125mW	Resistor	4,00
S1, S2	SW-PB	Momentani push button	Switch	2,00
U1, U7, U13	DS1100Z	SOIC 8	Digital Delay 50ns	3,00
U2, U8, U14	DS1100Z	SOIC 8	Digital Delay 250ns	3,00
U3, U10, U16, U25	74LVC1G00	SOT 25	SINGLE 2 INPUT POSITIVE AND GATE	4,00
U4, U6, U9, U12, U15, U18, U19, U20, U21, U22, U24	IL710	SOIC 8	High Speed Digital Isolator	11,00
U5, U11, U17	74LVC1G02	SOT 25	SINGLE 2 INPUT POSITIVE NOR GATE	3,00
U23	SN74HC109N	SOIC 16	Dual J-K Positive-Edge-Triggered Flip-Flop with Clear and Preset	1,00
U26	Traco 20W	TRACO 20W Through hole - duplicate	CC-CC Isolated converter 20W	1,00
U27, U28	Traco 2W	TRACO 1-15W SMD	CC-CC Isolated converter 2W	2,00

3.2 Placa de sensors

Part List

Bill of Materials For PCB Document [SensorsBoard.PcbDoc]

Source Data From:	**SensorsBoard.PcbDoc**
Project:	**SensorsBoard.PrjPcb**
Variant:	**None**
Report Date:	27/12/2015 12:57:55

Designator	**Comment**	**Footprint**	**Description**	**Quantity**
C1, C3, C6, C7, C8, C9, C11, C13, C18, C20, C23, C24, C25, C26, C27, C29, C31, C34, C35, C36, C37	Cap	SMD Ceramic Capacitor	Capacitor 100nF	21,00
C5, C10, C15, C28, C33, C38	Cap	Capacitor SMD Filtro	Capacitor 1,5uF	6,00
C16, C17, C19, C21, C22	Cap Pol1	SMD Pol. Capacitor	Polarized Capacitor 47uF	5,00
D1	Diode	TO 252	Default Diode	1,00
D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13	D Zener	Didoe SMD	Zener Diode 10V	12,00
D14	Led	LED 5mm R	Diode led	1,00
J1, J2, J3, J4, J5, J6, J7, J8	Jumper	Jumer 2	Jumper Wire	8,00
P1, P3, P4, P6, P8, P9	Header 2	BNC Connector	Header, 2-Pin	6,00
P2	From Corriente	Connector 6	Header, 6-Pin	1,00
P5	Input Source	Terminal Connector 2	Header, 2-Pin	1,00
P7	From Tension	Connector 6	Header, 6-Pin	1,00
R6, R14, R22, R30, R38, R46	Res1	SMD Resistor 125mW	Resistor 470Ω	6,00
R1, R9, R17, R25, R33, R41	Res1	SMD Resistor 125mW	Resistor 560kΩ	6,00
R3, R4, R5, R11, R12, R13, R19, R20, R21, R27, R28, R29, R35, R36, R37, R43, R44, R45	Res1	SMD Resistor 125mW	Resistor 470kΩ	18,00
R7, R15, R23, R31, R39, R47	Res1	SMD Resistor 125mW	Resistor 200Ω	6,00
R2, R8, R10, R16, R18, R24, R26, R32, R34, R40, R42, R48	RPot	SMD Variable Resistor	Potentiometer 500kΩ	12,00
U1, U2, U3, U4, U5,	TL082D	SOIC 8	JFET-Input Operational Amplifier	9,00
U10, U11	Traco 5W	TRACO 6W	CC-CC Isolated converter 5W	2,00

3.3 Placa sensors de tensió

Part List

Bill of Materials For PCB Document [TensionBoard.PcbDoc]

Source Data From: TensionBoard.PcbDoc
Project: TensionBoard.PrjPcb
Variant: None

Report Date: 27/12/2015 13:57:54

Designator	Comment	Footprint	Description	Quantity
C1, C3	Cap Pol1	SMD Pol. Capacitor	Polarized Capacitor 47uF	2,00
C2, C4	Cap	SMD Ceramic Capacitor	Capacitor 100nF	2,00
J1, J2, J3, J4, J5, J6	Faxton	Faxton 6.35		6,00
P1	From Sensors Board	HDR1X6	Header, 6-Pin	1,00
R1, R2, R3, R4, R5, R6, R7	Res1	Resistor Film	Resistor 20kΩ	7,00
U1, U2, U3	LV25-P	LV25-P	LV25-P	3,00

3.4 Placa dels sensors de corrent

Part List

Bill of Materials For PCB Document [CurrentBoard.PcbDoc]

Source Data From: CurrentBoard.PcbDoc
Project: CurrenBoard.PrjPcb
Variant: None

Report Date: 27/12/2015 14:05:33

Designator	Comment	Footprint	Description	Quantity
C1, C3	Cap Pol1	SMD Pol. Capacitor	Polarized Capacitor 47uF	2,00
C2, C4	Cap	SMD Ceramic Capacitor	Capacitor 100nF	2,00
J1, J2, J3, J4, J5, J6	Faxton	Faxton 6.35		6,00
P1	From Sensors Board	HDR1X6	Header, 6-Pin	1,00
U1, U2, U3	LV25-P	LA25-NP	LA25-NP	3,00

3.5 Plaques del bus de continua

Part List

Bill of Materials For BusDC Document [PCBBusDC.PcbDoc]

Source Data From:	**PCBBusDC.PcbDoc**
Project:	**BusDC.PrjPcb**
Variant:	**None**

Report Date: 27/12/2015 16:00:23

Designator	Comment	Footprint	Description	Quantity
C1, C2, C3	Cap1	Polypropylene Film Capacitor	Capacitor 100µF	3,00
C4, C5, C10, C11	Cap2	Polypropylene Film Capacitor	Capacitor 30µF	4,00
C6, C7, C8, C9, C12, C13, C14, C15	Cap3	Polypropylene Film Capacitor	Capacitor 10µF	8,00

4 PRESSUPOST

4.1 Placa de temps morts

Price List

Bill of Materials For PCB Document [PCBSiC2.PcbDoc]

Source Data From:	**PCBSiC2.PcbDoc**
Project:	**DeadBandSiC.PrjPcb**
Variant:	**None**

Report Date: 27/12/2015 12:39:34

Designator	Description	Quantity	Unit price (€)	Total price element (€)
C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13, C14, C15, C16, C17, C18, C19, C20, C21, C22, C23, C24, C25, C26, C27, C28, C29, C30, C31, C32, C33, C34, C35, C36, C37, C38, C40, C45, C46, C49, C50, C52, C54	Capacitor 100nF	45,00	0,39 €	17,55 €
C39, C41, C42, C43, C44, C47, C48, C51, C53	Polarized Capacitor 47uF	9,00	5,23 €	47,07 €
D1	Diode led	1,00	0,33 €	0,33 €
D2	Diode led	1,00	0,23 €	0,23 €
D3	Default Diode	1,00	3,91 €	3,91 €
J1, J2, J3, J4, J5, J6, J7, J8, J9, J10, J11, J12, J13, J14, J15, J16, J17, J18, J19, J20, J21, J22, J23, J24, J25, J26, J27, J28, J29, J30, J31, J32, J33, J34, J35, J36	Jumper Wire	36,00	0,10 €	3,56 €
P1	Header, 15-Pin	1,00	4,47 €	4,47 €
P2	Header, 13-Pin, Dual row	1,00	18,55 €	18,55 €
P3	Header, 2-Pin	1,00	3,01 €	3,01 €
R1, R2, R3, R4	Resistor	4,00	0,01 €	0,04 €
S1, S2	Switch	2,00	4,21 €	8,42 €
U1,U7,U13	Digital Delay 50ns	3,00	6,11 €	18,33 €
U2, U8, U14	Digital Delay 250ns	3,00	4,58 €	13,74 €
U3, U10, U16, U25	SINGLE 2 INPUT POSITIVE AND GATE	4,00	0,73 €	2,91 €
U4, U6, U9, U12, U15, U18, U19, U20, U21, U22, U24	High Speed Digital Isolator	11,00	4,43 €	48,73 €
U5, U11, U17	SINGLE 2 INPUT POSITIVE NOR GATE	3,00	0,64 €	1,91 €
U23	Dual J-K Positive-Edge-Triggered Flip-Flop with Clear and Preset	1,00	0,11 €	0,11 €
U26	CC-CC Isolated converter 20W	1,00	23,30 €	23,30 €
U27, U28	CC-CC Isolated converter 2W	2,00	54,20 €	108,40 €

Total price **324,58 €**

4.2 Placa de sensors

Price List

Sensors Board - Current Acondicioner

Source Data From: SensorsBoard.PrjPcb
Project: SensorsBoard.PrjPcb
Variant: None

Report Date: 27/12/2015 13:24:07

Designator	Description	Quantity	Unit price (€)	Total price element (€)
C1, C3, C6, C7, C8, C9, C11, C13, C18, C20, C23, C24, C25, C26, C27, C29, C31, C34, C35, C36, C37	Capacitor 100nF	21,00	0,3940 €	8,27 €
C5, C10, C15, C28, C33, C38	Capacitor 1,5uF	6,00	0,3300 €	1,98 €
C16, C17, C19, C21, C22	Polarized Capacitor 47uF	5,00	5,2300 €	26,15 €
D1	Default Diode	1,00	0,7820 €	0,78 €
D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13	Zener Diode 10V	12,00	0,3460 €	4,15 €
D14	Diode led	1,00	0,2280 €	0,23 €
J1, J2, J3, J4, J5, J6, J7, J8	Jumper Wire	8,00	0,0990 €	0,79 €
P1, P3, P4, P6, P8, P9	Header, 2-Pin	6,00	4,7300 €	28,38 €
P2	Header, 6-Pin	1,00	0,5000 €	0,50 €
P5	Header, 2-Pin	1,00	0,7900 €	0,79 €
P7	Header, 6-Pin	1,00	0,5000 €	0,50 €
R6, R14, R22, R30, R38, R46	Resistor 470Ω	6,00	0,0200 €	0,12 €
R1, R9, R17, R25, R33, R41	Resistor 560kΩ	6,00	0,0190 €	0,11 €
R3, R4, R5, R11, R12, R13, R19, R20, R21, R27, R28, R29, R35, R36, R37, R43, R44, R45	Resistor 470kΩ	18,00	0,0300 €	0,54 €
R7, R15, R23, R31, R39, R47	Resistor 200Ω	6,00	0,1900 €	1,14 €
R2, R8, R10, R16, R18, R24, R26, R32, R34, R40, R42, R48	Potentiometer 500kΩ	12,00	2,6300 €	31,56 €
U1, U2, U3, U4, U5, U6, U7, U8, U9	JFET-Input Operational Amplifier	9,00	0,6150 €	5,54 €
U10, U11	CC-CC Isolated converter 5W	2,00	26,7000 €	53,40 €
U1, U2, U3	Current sensor	3,00	19,2100 €	57,63 €
U1, U2, U3	Voltage sensor	3,00	53,3400 €	160,02 €

Total price **382,59 €**

4.3 Plaques del bus de continua

Price List — **Bill of Materials For BusDC Document [PCBBusDC.PcbDoc]**

Source Data From: PCBBusDC.PcbDoc
Project: BusDC.PrjPcb
Variant: None

Report Date: 27/12/2015 16:00:23

Designator	Description	Quantity	Unit price (€)	Total price element (€)
C1, C2, C3	Capacitor 100µF	3,00	33,50 €	100,50 €
C4, C5, C10, C11	Capacitor 30µF	4,00	11,15 €	44,60 €
C6, C7, C8, C9, C12, C13, C14, C15	Capacitor 10µF	8,00	7,63 €	61,04 €

Total price	**206,14 €**

4.4 Pressupost total

Price List — **Total**

Source Data From:
Project: Total project
Variant: None

Report Date: 02/04/2016 12:45:43

Designator	Description	Quantity	Unit price (€)	Total price element (€)
Material DeadTimeBoard	Material	1,00	324,58 €	324,58 €
DeadTimeBoard	Board	1,00	57,68 €	57,68 €
Material SensorsBoard	Material	1,00	382,59 €	382,59 €
Sensors Boards	Boards	1,00	238,12 €	238,12 €
Material BusCD	Material	1,00	206,14 €	206,14 €
BusDC Board1	Board	1,00		- €
BusDC Board 1 and 2	Boards	2,00		- €

Total price	**1.209,11 €**

5 FITXES TÈCNIQUES

5.1 Etapa de potencia

Datasheet: CCS050M12CM2,Rev. B

CCS050M12CM2
1.2kV, 50A Silicon Carbide Six-Pack (Three Phase) Module
Z-FET™ MOSFET and Z-Rec™ Diode

V_{DS}		1.2 kV
$R_{DS(on)}$	(T_J = 25°C)	25 mΩ
E_{OFF}	(T_J = 150°C)	0.6 mJ

Features
- Ultra Low Loss
- Zero Reverse Recovery Current
- Zero Turn-off Tail Current
- High-Frequency Operation
- Positive Temperature Coefficient on V_F and $V_{DS(on)}$
- Cu Baseplate, AlN DBC

System Benefits
- Enables Compact and Lightweight Systems
- High Efficiency Operation
- Ease of Transistor Gate Control
- Reduced Cooling Requirements
- Reduced System Cost

Applications
- Solar Inverters
- UPS and SMPS
- Induction Heating
- Regen Drives
- 3-Phase PFC
- Motor Drives

Package

Part Number	Package	Marking
CCS050M12CM2	Six-Pack	CCS050M12CM2

Maximum Ratings (T_C = 25°C unless otherwise specified)

Symbol	Parameter	Value	Unit	Test Conditions	Notes
V_{DS}	Drain - Source Voltage	1.2	kV		
V_{GS}	Gate - Source Voltage	+25/-10	V		
I_D	Continuous Drain Current	87	A	V_{GS} = 20 V, T_C = 25 °C	Fig. 26
		59		V_{GS} = 20 V, T_C = 90 °C	
$I_{D(pulse)}$	Pulsed Drain Current	250	A	Pulse width t_P = 250 µs Rate limited by T_{jmax}, T_C = 25°C	Fig. 28
T_J	Junction Temperature	150	°C		
T_C, T_{STG}	Case and Storage Temperature Range	-40 to +125	°C		
V_{isol}	Case Isolation Voltage	2.5	kV	DC, t = 1 min	
L_{Stray}	Stray Inductance	30	nH	Measured from pins 25-26 to 27-28	
M	Mounting Torque	5.0	N-m		
G	Weight	180	g		
P_D	Power Dissipation	312	W	T_C = 25 °C, T_J ≤ 150 °C	Fig. 27

Electrical Characteristics (T_C = 25 °C unless otherwise specified)

Symbol	Parameter	Min.	Typ.	Max.	Unit	Test Conditions	Note
$V_{(BR)DSS}$	Drain - Source Breakdown Voltage	1.2			kV	V_{GS} = 0 V, I_D = 100 μA	
$V_{GS(th)}$	Gate Threshold Voltage		2.3		V	V_{DS} = 10 V, I_D = 2.5 mA	
			1.6			V_{DS} = 10 V, I_D = 2.5 mA, T_J = 150 °C	
I_{DSS}	Zero Gate Voltage Drain Current		2	100	μA	V_{DS} = 1.2 kV, V_{GS} = 0V	
I_{GSS}	Gate-Source Leakage Current			0.5	μA	V_{GS} = 20 V, V_{DS} = 0V	
$R_{DS(on)}$	On State Resistance		25	34	mΩ	V_{GS} = 20 V, I_{DS} = 50 A	Fig. 4-7
			43	63		V_{GS} = 20 V, I_{DS} = 50 A, T_J = 150 °C	
g_{fs}	Transconductance		22		S	V_{DS} = 20 V, I_{DS} = 50 A	Fig. 8
			21			V_{DS} = 20 V, I_D = 50 A, T_J = 150 °C	
C_{iss}	Input Capacitance		2.810		nF	V_{DS} = 800 V, V_{GS} = 0 V f = 1 MHz, V_{AC} = 25 mV	Fig. 16,17
C_{oss}	Output Capacitance		0.393				
C_{rss}	Reverse Transfer Capacitance		0.014				
E_{on}	Turn-On Switching Energy		1.1		mJ	V_{DD} = 600 V, V_{GS} = +20V/-5V I_D = 50 A, R_G = 20 Ω Load = 200 μH T_J = 150 °C Note: IEC 60747-8-4 Definitions	Fig. 18
E_{Off}	Turn-Off Switching Energy		0.6		mJ		
$R_{G\ (int)}$	Internal Gate Resistance		1.5		Ω	f = 1 MHz, V_{AC} = 25 mV	
Q_{GS}	Gate-Source Charge		32		nC	V_{DD}= 800 V, I_D= 50 A	Fig. 15
Q_{GD}	Gate-Drain Charge		30				
Q_G	Total Gate Charge		180				
$t_{d(on)}$	Turn-on delay time		21		ns	V_{DD} = 800V, R_{LOAD} = 8 Ω V_{GS} = +20/-2V, R_G = 3.8 Ω T_J = 25 °C Note: IEC 60747-8-4 Definitions	Fig. 20-25
$t_{r(on)}$	V_{SD} fall time 90% to 10%		30		ns		
$t_{d(off)}$	Turn-off delay time		50		ns		
$t_{f(off)}$	V_{SD} rise time 10% to 90%		19		ns		

Free-Wheeling SiC Schottky Diode Characteristics

Symbol	Parameter	Min.	Typ.	Max.	Unit	Test Conditions	Note
V_{SD}	Diode Forward Voltage		1.5	1.7	V	I_F = 50 A, V_{GS} = 0	Fig. 9
			2.0	2.3		I_F = 50 A, T_J = 150 °C	
Q_C	Total Capacitive Charge		0.28		μC		
I_F	Continuous Forward Current		50		A	V_{GS} = -5 V, T_c = 90 °C	

Thermal Characteristics

Symbol	Parameter	Min.	Typ.	Max.	Unit	Test Conditions	Note
R_{thJCM}	Thermal Resistance Juction-to-Case for MOSFET		0.37	0.40	°C/W	T_c = 90 °C, P_D = 150 W	
R_{thJCD}	Thermal Resistance Juction-to-Case for Diode		0.42	0.43		T_c = 90 °C, P_D = 130 W	

NTC Characteristics

Symbol	Condition	Typ.	Max.	Unit
R_{25}	T_C = 25 ºC	5		kΩ
Delta R/R	T_C = 100 ºC, R_{100} = 481 Ω		±5	%
P_{25}	T_C = 25 ºC			mW
$B_{25/50}$	$R_2 = R_{25}\ \exp[B_{25/50}(1/T_2\text{-}1/(298.15K))]$	3380		K
$B_{25/80}$	$R_2 = R_{25}\ \exp[B_{25/80}(1/T_2\text{-}1/(298.15K))]$	3440		K

Typical Performance

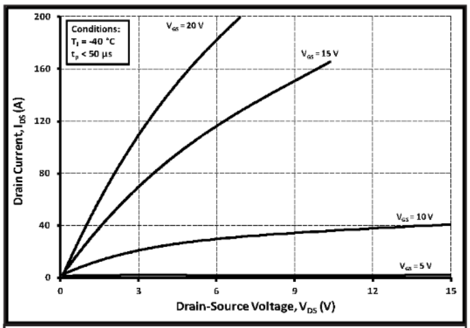


Figure 1. Typical Output Characteristics T_J = -40 °C

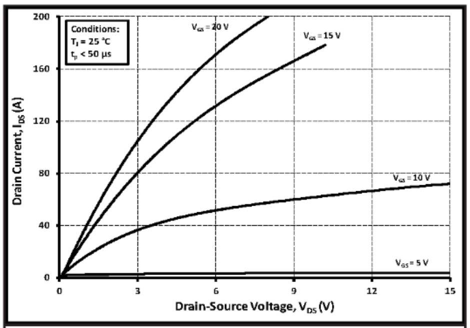


Figure 2. Typical Output Characteristics T_J = 25 °C

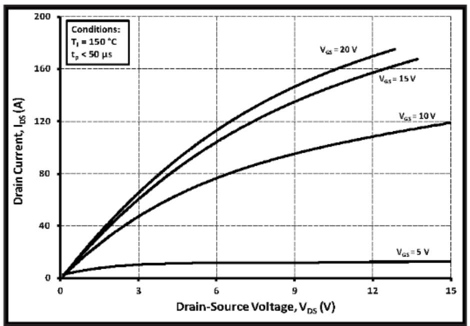


Figure 3. Typical Output Characteristics T_J = 150 °C

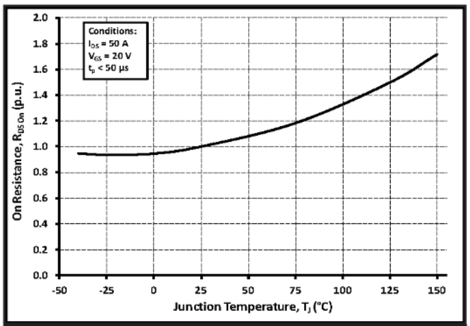


Figure 4. Normalized On-Resistance vs. Temperature

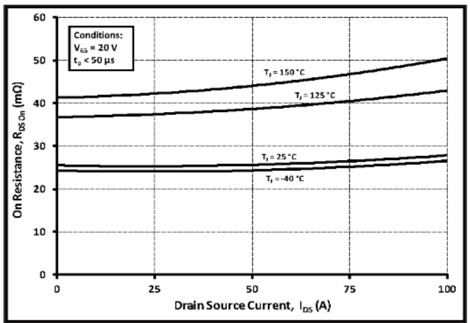


Figure 5. Normalized On-Resistance vs. Drain Current For Various Temperatures

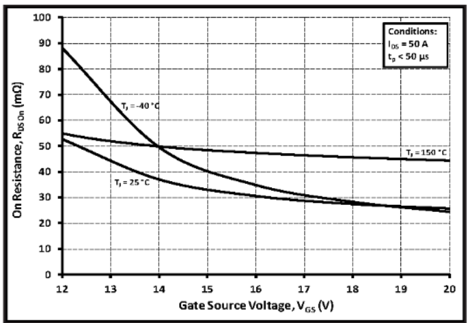


Figure 6. Normalized On-Resistance vs. Gate-Source Voltage for Various Temperatures

3 CCS050M12CM2,Rev. B

Typical Performance

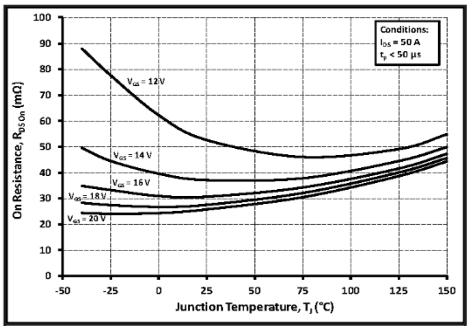


Figure 7. On-Resistance vs. Temperature for Various Gate-Source Voltages

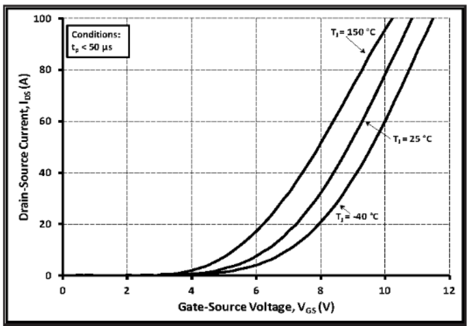


Figure 8. Transfer Characteristic for Various Junction Temperatures

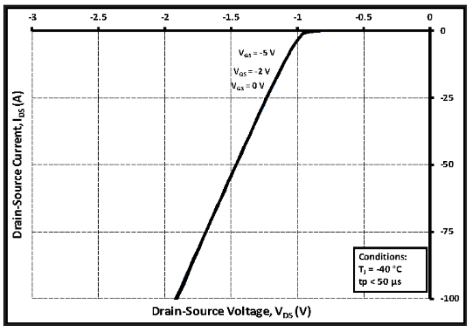


Figure 9. Diode Characteristic at -40 °C

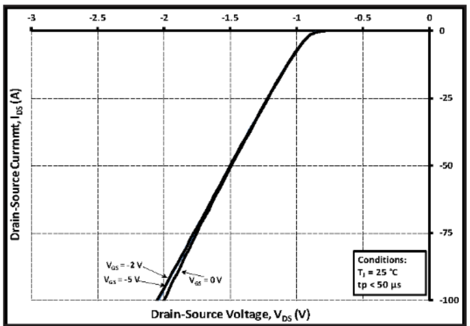


Figure 10. Diode Characteristic at 25 °C

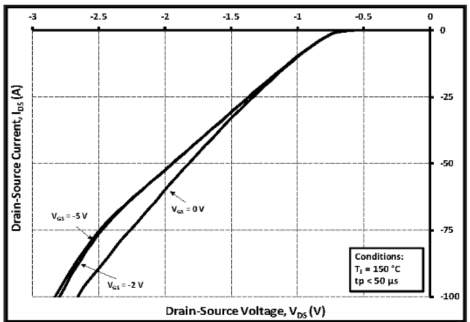


Figure 11. Diode Characteristic at 150 °C

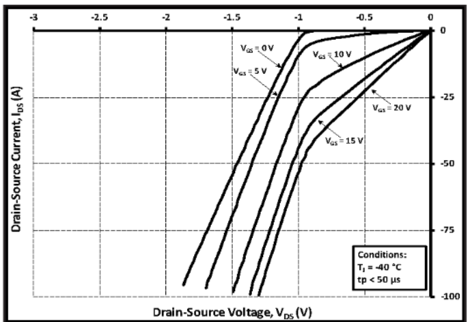


Figure 12. 3rd Quadrant Characteristic at -40 °C

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Typical Performance

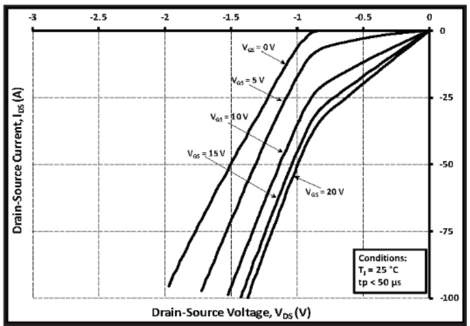

Figure 13. 3[rd] Quadrant Characteristic at 25 °C

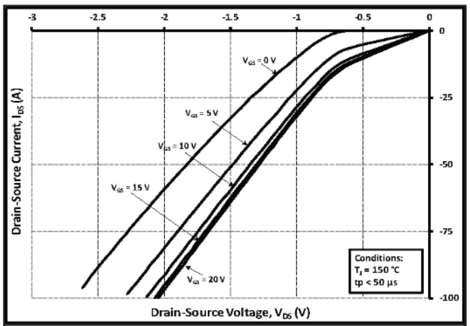

Figure 14. 3[rd] Quadrant Characteristic at 150 °C

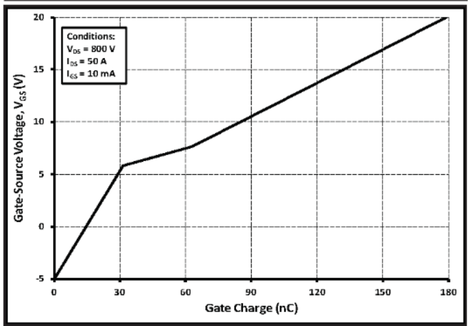

Figure 15. Typical Gate Charge Characteristics

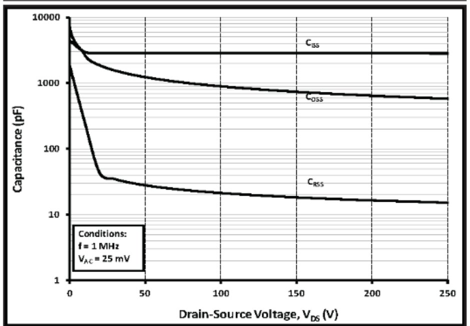

Figure 16. Typical Capacitances vs. Drain-Source Voltage (0 - 250 V)

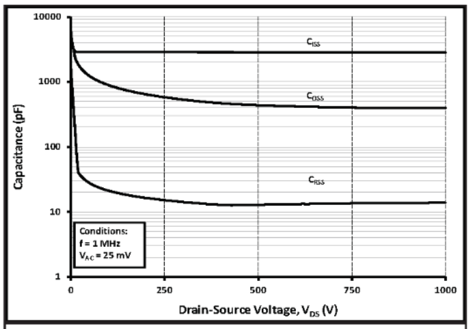

Figure 17. Typical Capacitances vs. Drain-Source Voltage (0 - 1 kV)

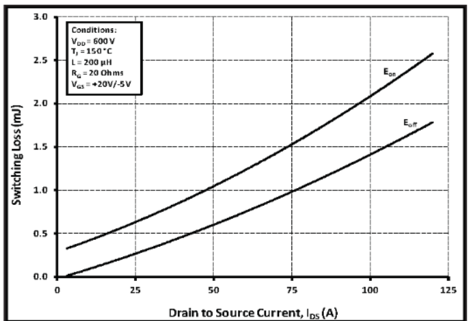

Figure 18. Inductive Switching Energy vs. Drain Current For V_{DS} = 600V, R_G = 20 Ω

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Typical Performance

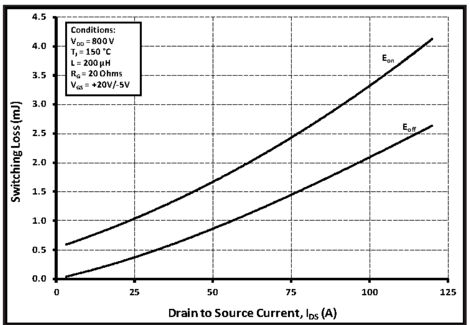


Figure 19. Inductive Switching Energy vs. Drain Current For V_{DS} = 800 V, R_G = 20 Ω

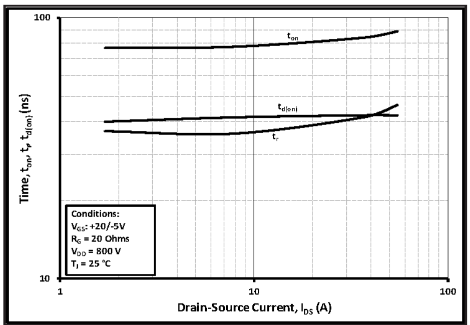


Figure 20. Turn-on Timing vs. Drain Current

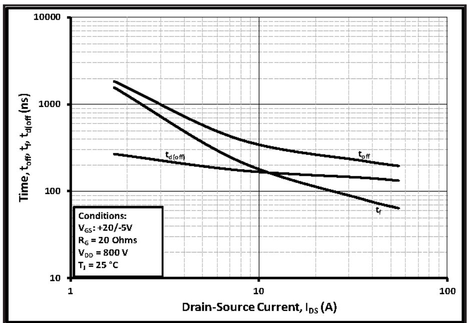


Figure 21. Turn-off Timing vs. Drain Current

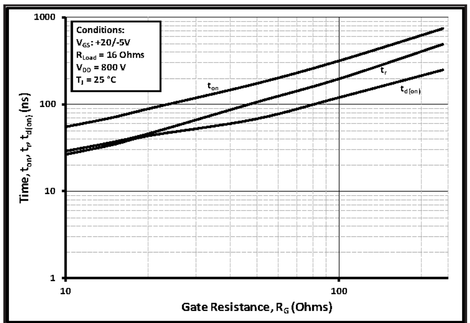


Figure 22. Turn-on Timing vs. External Gate Resistor

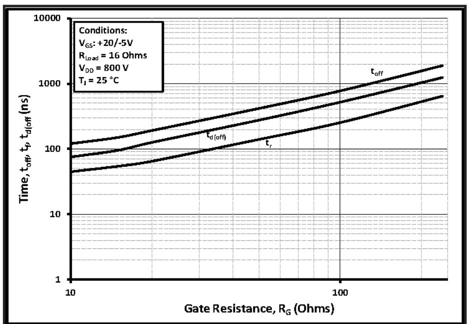


Figure 23. Turn-off Timing vs. External Gate Resistor

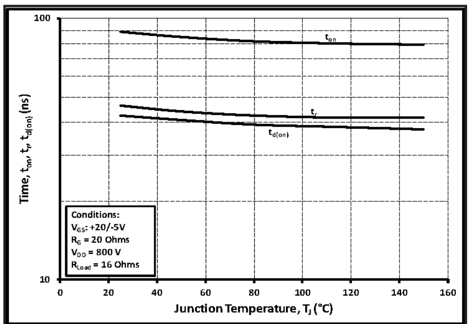


Figure 24. Turn-on Timing vs. Junction Temperature

Typical Performance

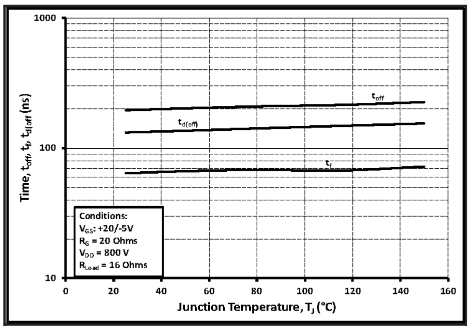


Figure 25. Turn-on Timing vs. Junction Temperature

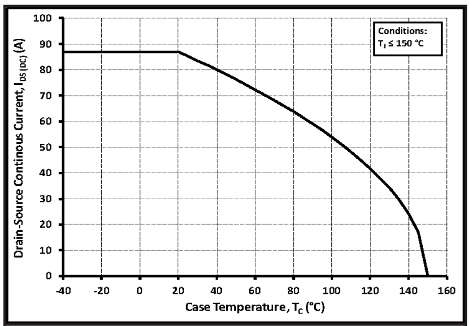


Figure 26. Continous Drain Current Derating vs Case Temperature

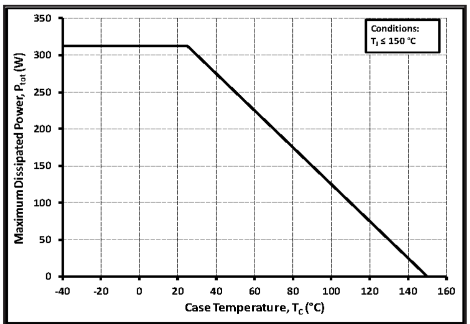


Figure 27. Maximum Power Dissipation (MOSFET) Derating vs Case Temperature

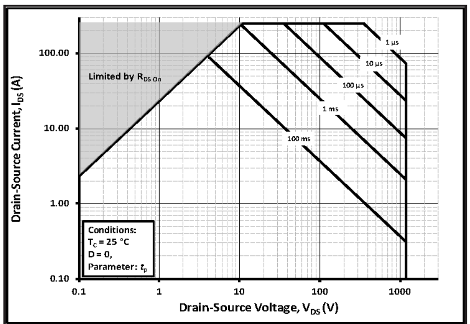


Figure 28. MOSFET Safe Operating Area

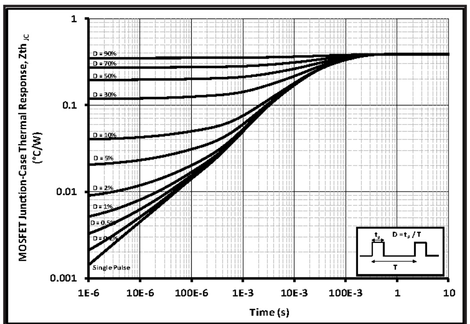


Figure 29. MOSFET Junction to Case Thermal Impedance

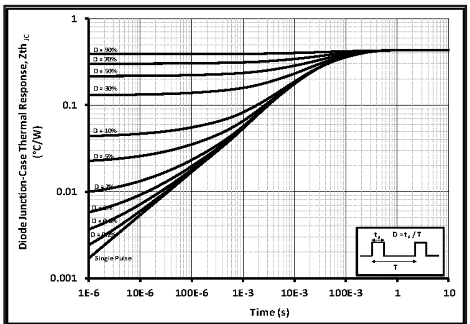


Figure 30. Diode Junction to Case Thermal Impedance

Typical Performance

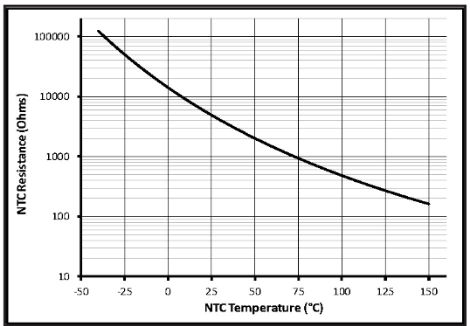


Figure 31. NTC Resistance vs NTC tTemperature

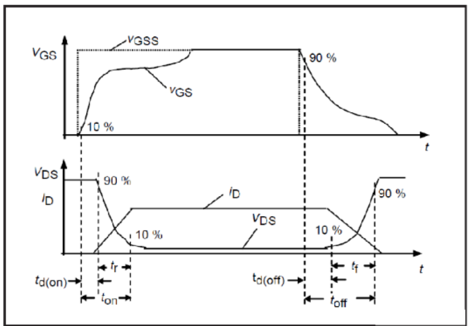
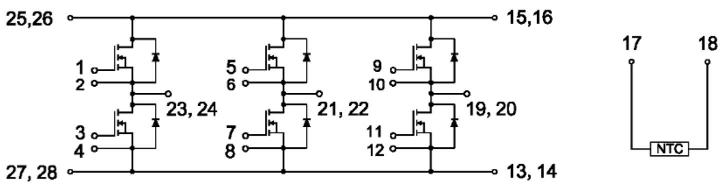


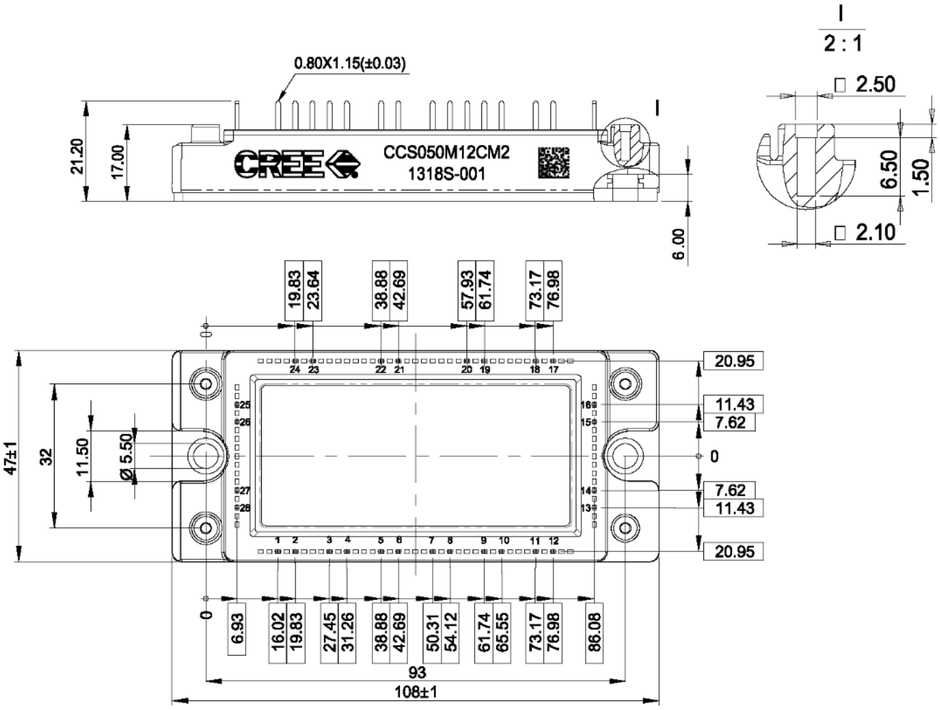
Figure 31. Resistive Switching Time Description

Module Application Note: The SiC MOSFET module switches at speeds beyond what is customarily associated with IGBT based modules. Therefore, special precautions are required to realize the best performance. The interconnection between the gate driver and module housing needs to be as short as possible. This will afford the best switching time and avoid the potential for device oscillation. Also, great care is required to insure minimum inductance between the module and link capacitors to avoid excessive V_{DS} overshoots.

Please Refer to application note: Design Considerations when using Cree SiC Modules Part 1 and Part 2. [CPWR-AN12, CPWR-AN13]

Package Dimensions (mm)





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Fax: +1.919.313.5451
www.cree.com/power

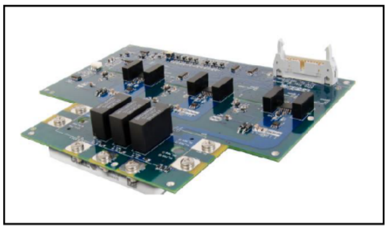
5.2 Placa de drivers

Six Channel SiC MOSFET Driver

Gate Driver for 1200V SiC MOSFET Power Module

Features

- 6 output channels
- Isolated power supply
- Direct mount low inductance design
- Short circuit protection
- Over temperature protection
- Under voltage protection



For use with Cree Module

- 45mm, 6-pak modules.

Part Number	Package	Marking
CGD15FB45P	PCBA	CGD15FB45P Rev2

Applications

- 6-pak Driver for 1.2kV, SiC MOSFET modules
- DC Bus voltage up to 900VDC

Absolute Maximum Ratings

Symbol	Parameter	Value	Unit	Test Conditions	Note
V_s	Power Supply Voltage	16	V	*Vs ramp rate >50V/sec*	
V_{IH}	Input signal voltage HIGH	5	V		
V_{IL}	Input signal voltage LOW	0	V		
$I_{O.pk}$	Output peak current	9	A		
$I_{O.avg.max}$	Ouput average current	2	A		
F_{Max}	Max. Switching frequency	150	kHz	*Vg=+20/-5, Rg = 10 Ω*	
V_{DS}	Max. Drain to source voltage	1200	V		
V_{isol}	Input to output isolation voltage	±1200	V		
T_{op}	Operating temperature	-25 to 70	ºC		
T_{stg}	Storage temperature	-40 to 85	ºC		

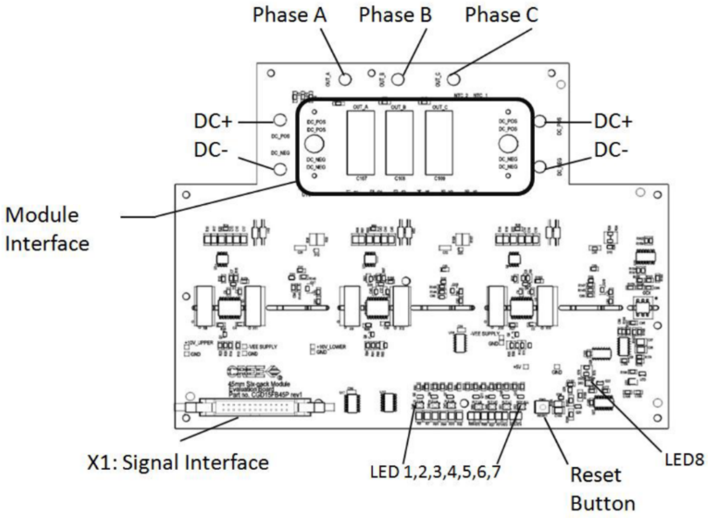
Characteristics

Symbol	Parameter	Value			Unit	Test Conditions	Notes
		Min	Typ	Max			
V_S	Supply voltage	13.0	15.0	16.0	V		
V_I	Input signal voltage on/off		5/0		V		
I_{SO}	Supply current (no load)		330	420	mA	70C	
	Supply current (switching)		830	1000		70C, 150khz	
V_{IT+}	Input threshold voltage HIGH	3.5			V		
V_{IT-}	Input threshold voltage LOW			1.5	V		
T_{don}	Turn on propogation delay		210	280	nS		
T_{doff}	Turn off propogation delay		225	295	nS		
T_{err}	Pulse width for resetting fault	800			nS		
W	Weight		300		g		
MTBF	Mean time between failure		1.5		10^6h		

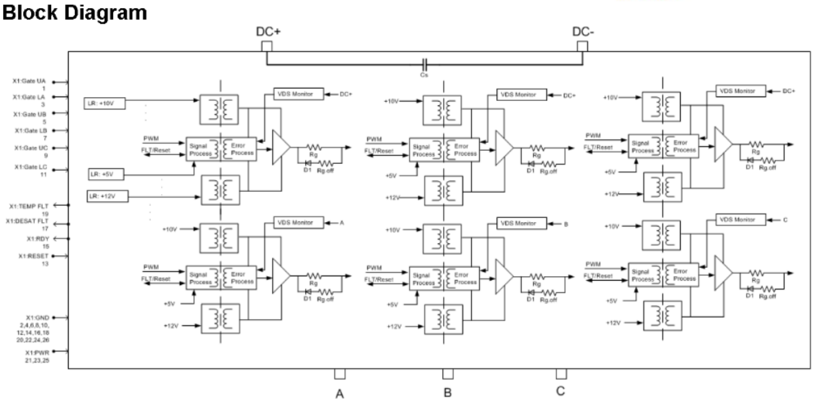
1 CGD15FB45P Rev -

CREE

Driver Overview



Block Diagram



Note: Default gate resistor for Rg is 10Ω for gate ON and OFF. The user can control the gate turn ON and OFF speed by changing Rg to a lower value and gain better MOSFET switching efficiency. The user can also control the Gate turn-ON and OFF speed independently by populating Rg.off and D1. Cs is made up of 3x 2.2nF, 1.2kV film capacitors.

2 CGD15FB45P Rev -

X1 – 26 pos Signal connector (FCI p/n# 71918-126LF)

1	PWM_Upper_A (5V Logic)	2	COMMON
3	PWM_Lower_A (5V Logic)	4	
5	PWM_Upper_B (5V Logic)	6	
7	PWM_Lower_B (5V Logic)	8	
9	PWM_Upper_C (5V Logic)	10	
11	PWM_Lower_C (5V Logic)	12	
13	/RST (normally hi)	14	
15	RDY (normally hi)	16	
17	DESAT FAULT (normally low)	18	
19	OVER_TEMP_FLT (normally low)	20	
21	PWR In (Vs)	22	
23		24	
25		26	

LED Status Indicators			
L1	RED led, illuminated when Phase A upper switch has a desat fault.	**L2**	RED led, illuminated when Phase A lower switch has a desat fault.
L3	RED led, illuminated when Phase B upper switch has a desat fault.	**L4**	RED led, illuminated when Phase B lower switch has a desat fault.
L5	RED led, illuminated when Phase C upper switch has a desat fault.	**L6**	RED led, illuminated when Phase C lower switch has a desat fault.
L7	GREEN led, illuminated when power is present and all faults are clear.	**L8**	RED led, illuminated when there is an over temp fault.

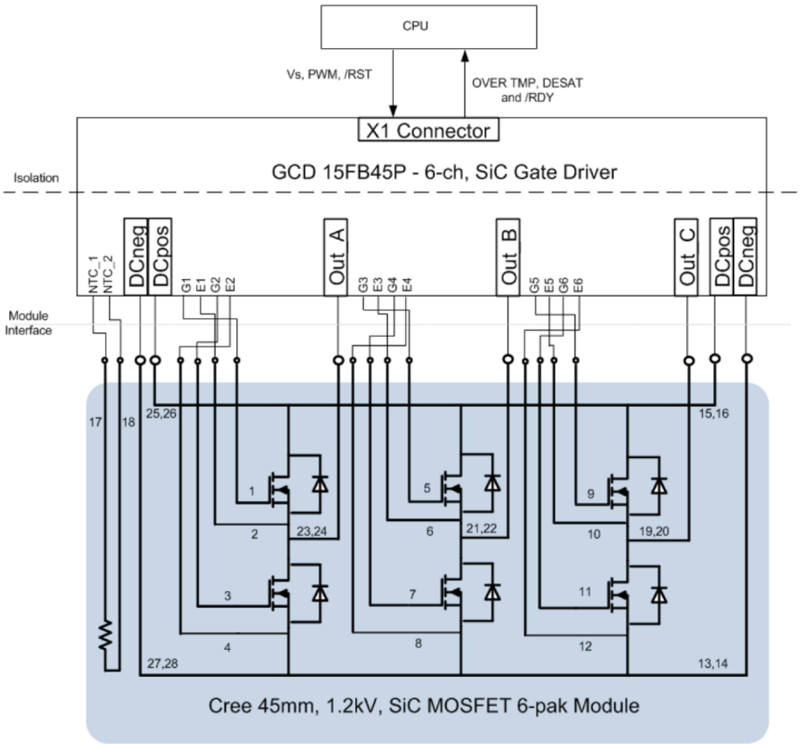
Fault Handling

Each of the six gate drive channels is protected by a desaturation circuit. In the event of a short circuit, the voltage across the MOSFET (V_{DS}) rises until it hits a threshold which causes the desaturation circuit to drive all six gate drive channels to their off state. Pin 17 of the 26 pin main signal connector toggles high when a desaturation event occurs. There will also be a red LED (L1-L6) illuminated for the gate drive channel(s) that activated the desaturation protection. Once the fault is cleared, the circuit can be reset with the onboard reset button or remotely by pulling pin 13 of the 26 pin ribbon connector to common.

There is an overtemperature protection circuit that turns off all the gates in the event an overtemperature is detected. The overtemperature circuit reads the value of the six pack module's onboard NTC. When the NTC reaches a value corresponding to 115C, the overtemperature circuit is activated and all six gate drive channels are driven to their low state. Pin 19 of the 26 pin ribbon connector is toggled high when an overtemperature fault occurs.

3 CGD15FB45P Rev -

Typical Application



Mechanical Instructions

Designed to directly mount to Cree 45 mm style power modules, the 6-ch gate driver also has several other mounting holes to secure the assembly.

Attach the gate driver board to the power module via the 4x Module screw holes (see diagram below) using the recommended hardware in Table 1. Then solder the 28x solder pins via the solder pin holes to electrically connect the driver board to the power module. The solder must not exceed 260°C and the solder per pin must not exceed 10 seconds. The solder joints should be in accordance with IPC A 610 Rev D (or later) – Class 3 to ensure an optimal connection between the module and gate driver board.

The module plus driver board assembly must be further supported by securing the assembly to standoffs via the 9x Mounting holes shown in the figure below.

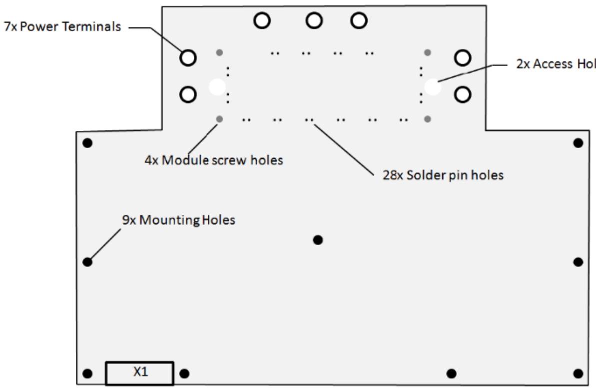


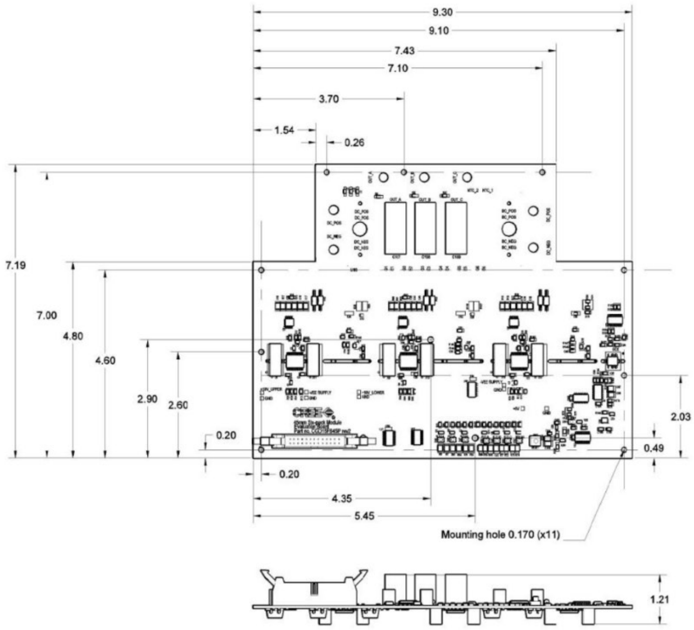
Table 1 Hardware List

Ref	Description	Hardware	Locations	Torque
Module screw holes	2.5mm clearance holes for mounting screws to secure the module to the printed circuit board assembly.	M2.5 x 4mm	4x	0.5 Nm
Mounting holes	4.3mm clearance holes for screws to secure the circuit assembly to stand-offs for additional support.	6-32 x 5/6" Zinc Plated pan head screw /w internal tooth washer.	9x	0.9 Nm
Access holes	10mm clearance hole to provide access to the screw that secure the module to the heatsink.	n/a	2x	n/a
Solder pin holes	1.6mm plated holes for solder pins from power module.	Solder pins from power module	28x	n/a
Power terminals	5mm holes to secure power cables.	*	7x	

** Power terminal holes are sized to accept a PENN broaching nut (#P-KFS2-032). A 10-32, 6mm screw with a captured lock washer should be used with this broaching nut.*

5 CGD15FB45P Rev -

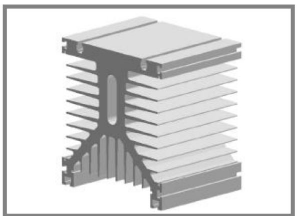
Mechanical Drawing (units in Inches)



Cree, Inc.
4600 Silicon Drive
Durham, NC 27703
USA Tel: +1.919.313.5300
Fax: +1.919.313.5451
www.cree.com/power

5.3 Dissipador

P 3



Heatsink

Standard lengths	n	b / d Ø mm	R_{thha} natural cooling K/W	R_{thha} with Fan SKF 3-230-01 K/W	w kg
P 3/120	1	20	0,55 (100W)	0,167	2,1
	3		0,43 (150W)	0,147	
P 3/180	2	20	0,39 (150W)	0,132	3,1
	3		0,36 (180W)	0,12	
	6		0,33 (200W)	0,108	
	1	34		0,144	
	3			0,118	
P 3/300	3	34		0,0847	5,3

For isolated power modules

P 3

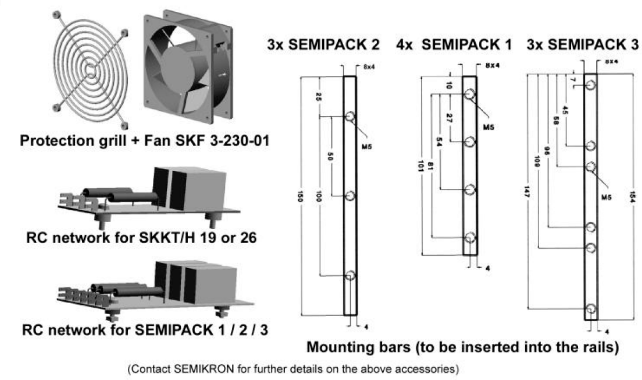
Features

- Intended for isolated power modules, SEMIPACK (1 to 4) and SEMITRANS 2 range
- Integrated rails allow for easy mounting of the modules
- Available in various lengthes
- Best fitted fan : SKF 3-230-01
- Mounting bar rails available (see sketches)

Dimensions in mm

P3 general profile dimensions (w = 17,6 kg/m)

Dimensions in mm



P 3 standard accessories

1 17-03-2005 ADR

P 3 SEMIKRON, leading manufacturer of diode thyristor power semiconductor modules

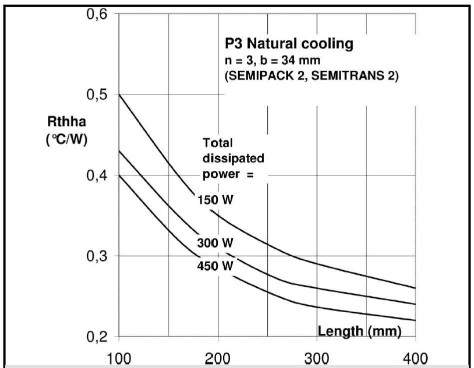


Fig.3a Total thermal resistance vs. length

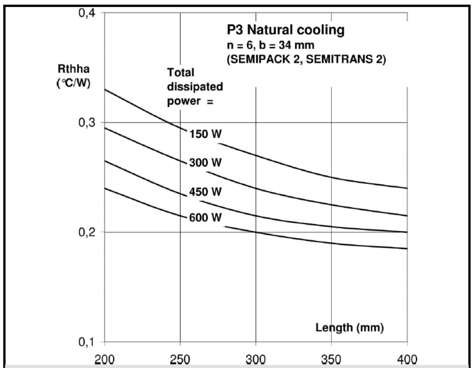


Fig.3b Total thermal resistance vs. length

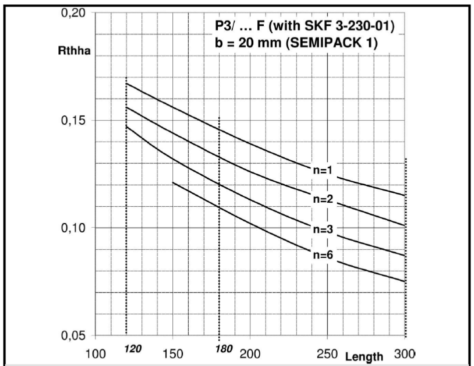


Fig.6 Total thermal resistance versus length

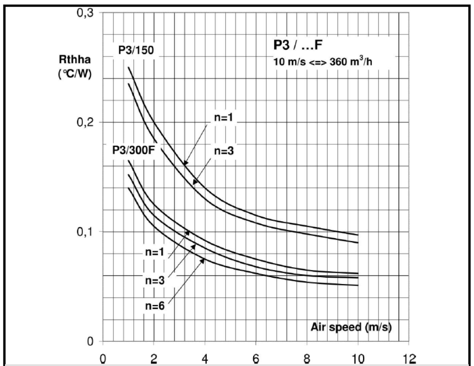


Fig.7 Total thermal resistance vs.air velocity

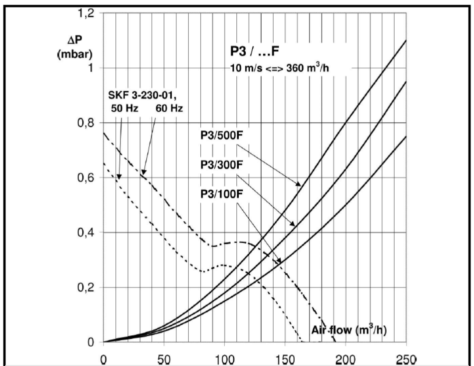


Fig.8 Pressure drop vs air flow, and associated fan SKF3

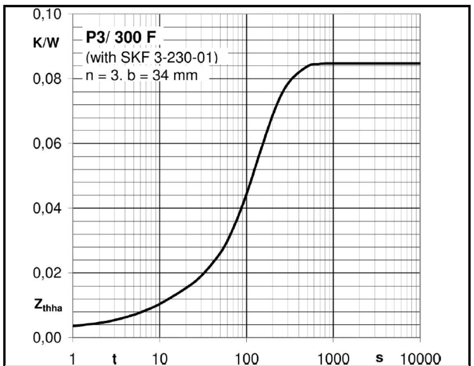


Fig.10 Total transient thermal impedance vs.time

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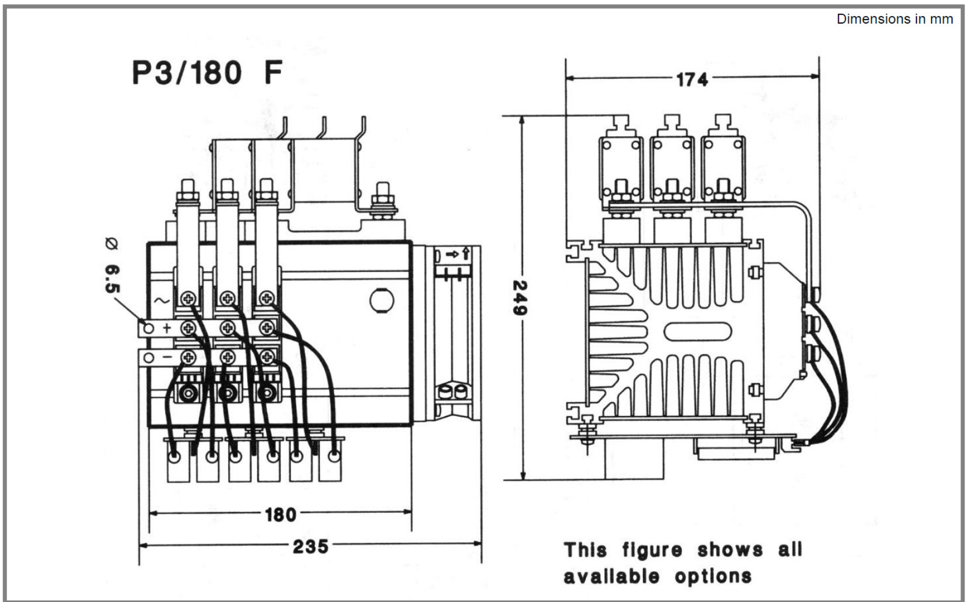
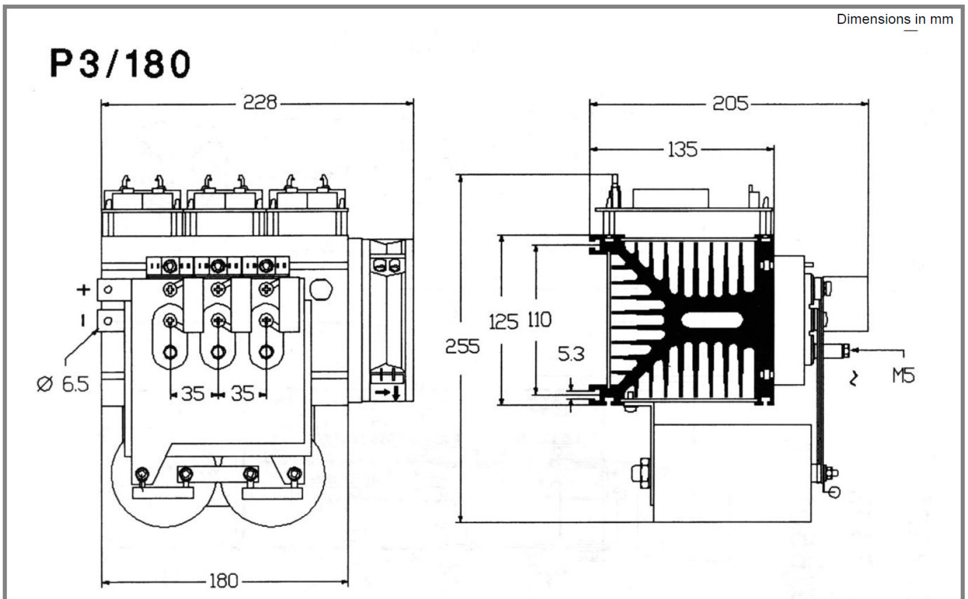


1.Application example using heatsink P 3/180 and SEMIPACK modules to give a three phase bridge



2.Application example using SEMITRANS modules to give a B6CI configuration

3 17-03-2005 ADR © by SEMIKRON

5.4 Sensors de corrent

LEM

Current Transducer LA 25-NP

I_{PN} = 5-6-8-12-25 At

For the electronic measurement of currents: DC, AC, pulsed..., with galvanic isolation between the primary circuit and the secondary circuit.

5 Year Warranty · CE · RoHS COMPLIANT 2002/95/EC 16080 · c UL us

Electrical data

I_{PN}	Primary nominal current rms		25				At
I_{PM}	Primary current, measuring range		0 .. ± 36				At
R_M	Measuring resistance @		T_A = 70°C		T_A = 85°C		
			$R_{M\,min}$	$R_{M\,max}$	$R_{M\,min}$	$R_{M\,max}$	
	with ± 15 V	@ ± 25 At_{max}	100	320	100	315	Ω
		@ ± 36 At_{max}	100	190	100	185	Ω
I_{SN}	Secondary nominal current rms		25				mA
K_N	Conversion ratio		1-2-3-4-5 : 1000				
V_C	Supply voltage (± 5 %)		± 15				V
I_C	Current consumption		10 + I_S				mA

Accuracy - Dynamic performance data

X	Accuracy @ I_{PN}, T_A = 25°C		± 0.5		%
ε_L	Linearity error		< 0.2		%
			Typ	Max	
I_O	Offset current [1] @ I_P = 0, T_A = 25°C		± 0.05	± 0.15	mA
I_{OM}	Magnetic offset current [2] @ I_P = 0 and specified R_M, after an overload of 3 x I_{PN}		± 0.05	± 0.15	mA
I_{OT}	Temperature variation of I_O	0°C .. + 25°C	± 0.06	± 0.25	mA
		+ 25°C .. + 70°C	± 0.10	± 0.35	mA
		- 25°C .. + 85°C		± 0.5	mA
		- 40°C .. + 85°C		± 1.2	mA
t_r	Response time [3] to 90 % of I_{PN} step		< 1		μs
di/dt	di/dt accurately followed		> 50		A/μs
BW	Frequency bandwidth (- 1 dB)		DC .. 150		kHz

General data

T_A	Ambient operating temperature		- 40 .. + 85	°C
T_S	Ambient storage temperature		- 45 .. + 90	°C
R_P	Primary coil resistance per turn	@ T_A = 25°C	< 1.25	mΩ
R_S	Secondary coil resistance	@ T_A = 70°C	110	Ω
		@ T_A = 85°C	115	Ω
R_{IS}	Isolation resistance @ 500 V, T_A = 25°C		> 1500	MΩ
m	Mass		22	g
	Standards		EN 50178: 1997	

Notes: [1] Measurement carried out after 15 mn functioning
[2] The result of the coercive field of the magnetic circuit
[3] With a di/dt of 100 A/μs.

Features

- Closed loop (compensated) current transducer using the Hall effect
- Isolated plastic case recognized according to UL 94-V0.

Advantages

- Excellent accuracy
- Very good linearity
- Low temperature drift
- Optimized response time
- Wide frequency bandwidth
- No insertion losses
- High immunity to external interference
- Current overload capability.

Applications

- AC variable speed drives and servo motor drives
- Static converters for DC motor drives
- Battery supplied applications
- Uninterruptible Power Supplies (UPS)
- Switched Mode Power Supplies (SMPS)
- Power supplies for welding applications.

Application domain

- Industrial.

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Current Transducer LA 25-NP

Isolation characteristics

V_d	Rms voltage for AC insulation test, 50 Hz, 1 min	2.5	kV
$\hat{V}_w$	Impulse withstand voltage 1.2/50 µs	9	kV
		Min	
dCp	Creepage distance	10.63	mm
dCI	Clearance	10.63	mm
CTI	Comparative Tracking Index (group IIIa)	175	

Applications examples

According to EN 50178 and IEC 61010-1 standards and following conditions:

- Over voltage category OV 3
- Pollution degree PD2
- Non-uniform field

	EN 50178	**IEC 61010-1**
dCp, dCI, $\hat{V}_w$	Rated insulation voltage	Nominal voltage
Basic insulation	1700 V	1700 V
Reinforced insulation	600 V	600 V

Safety

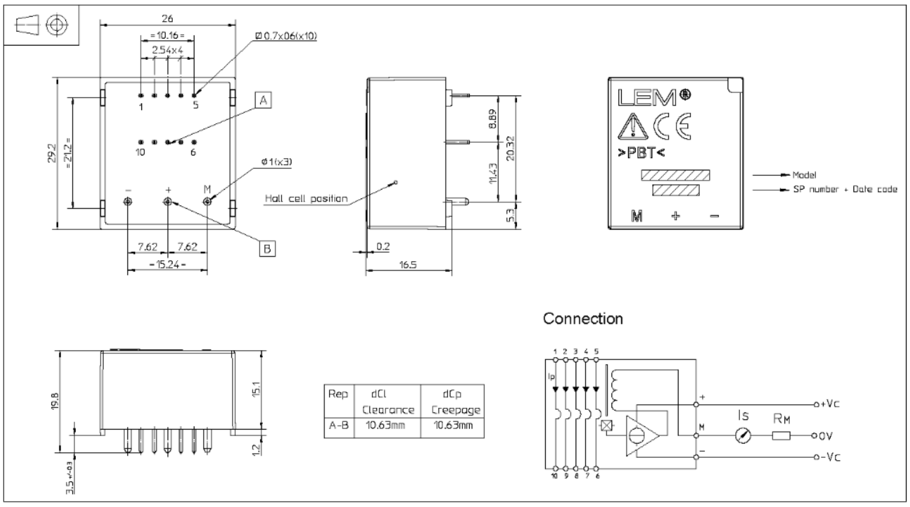
This transducer must be used in electric/electronic equipment with respect to applicable standards and safety requirements in accordance with the manufacturer's operating instructions.

Caution, risk of electrical shock

When operating the transducer, certain parts of the module can carry hazardous voltage (eg. primary busbar, power supply).
Ignoring this warning can lead to injury and/or cause serious damage.
This transducer is a build-in device, whose conducting parts must be inaccessible after installation.
A protective housing or additional shield could be used.
Main supply must be able to be disconnected.

LEM

Dimensions LA 25-NP (in mm)



Number of primary turns	Primary current nominal I_{PN} [A]	Primary current maximum I_P [A]	Nominal output current I_{SN} [mA]	Turns ratio K_N	Primary resistance R_P [mΩ]	Primary insertion inductance L_P [µH]	Recommended connections
1	25	36	25	1 / 1000	0.3	0.023	5 4 3 2 1 IN / OUT 6 7 8 9 10
2	12	18	24	2 / 1000	1.1	0.09	5 4 3 2 1 IN / OUT 6 7 8 9 10
3	8	12	24	3 / 1000	2.5	0.21	5 4 3 2 1 IN / OUT 6 7 8 9 10
4	6	9	24	4 / 1000	4.4	0.37	5 4 3 2 1 IN / OUT 6 7 8 9 10
5	5	7	25	5 / 1000	6.3	0.58	5 4 3 2 1 IN / OUT 6 7 8 9 10

Mechanical characteristics

- General tolerance ± 0.2 mm
- Fastening & connection of primary 10 pins 0.7 x 0.6 mm
- Fastening & connection of secondary 3 pins Ø 1 mm
- Recommended PCB hole 1.2 mm

Remarks

- I_S is positive when I_P flows from terminals 1, 2, 3, 4, 5 to terminals 10, 9, 8, 7, 6.
- This is a standard model. For different versions (supply voltages, turns ratios, unidirectional measurements...), please contact us.

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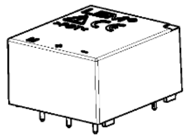
5.5 Sensors de tensió

Voltage Transducer LV 25-P

I_{PN} = 10 mA
V_{PN} = 10 .. 500 V

For the electronic measurement of currents: DC, AC, pulsed..., with galvanic isolation between the primary circuit and the secondary circuit.

16084



Electrical data

I_{PN}	Primary nominal current rms		10		mA
I_{PM}	Primary current, measuring range		0 .. ± 14		mA
R_M	Measuring resistance		$R_{M\,min}$	$R_{M\,max}$	
	with ± 12 V	@ ± 10 mA $_{max}$	30	190	Ω
		@ ± 14 mA $_{max}$	30	100	Ω
	with ± 15 V	@ ± 10 mA $_{max}$	100	350	Ω
		@ ± 14 mA $_{max}$	100	190	Ω
I_{SN}	Secondary nominal current rms		25		mA
K_N	Conversion ratio		2500 : 1000		
V_C	Supply voltage (± 5 %)		± 12 .. 15		V
I_C	Current consumption		10 (@ ± 15 V) + I_S		mA

Accuracy - Dynamic performance data

X_G	Overall accuracy @ I_{PN}, T_A = 25°C @ ± 12 .. 15 V		± 0.9		%
		@ ± 15 V (± 5 %)	± 0.8		%
ε_L	Linearity error		< 0.2		%
			Typ	Max	
I_O	Offset current @ I_P = 0, T_A = 25°C			± 0.15	mA
I_{OT}	Temperature variation of I_O	0°C .. + 25°C	± 0.06	± 0.25	mA
		+ 25°C .. + 70°C	± 0.10	± 0.35	mA
t_r	Response time [1] to 90 % of I_{PN} step		40		µs

General data

T_A	Ambient operating temperature		0 .. + 70	°C
T_S	Ambient storage temperature		- 25 .. + 85	°C
R_P	Primary coil resistance	@ T_A = 70°C	250	Ω
R_S	Secondary coil resistance	@ T_A = 70°C	110	Ω
m	Mass		22	g
	Standard		EN 50178: 1997	

Note: [1] R_1 = 25 kΩ (L/R constant, produced by the resistance and inductance of the primary circuit).

Features

- Closed loop (compensated) current transducer using the Hall effect
- Isolated plastic case recognized according to UL 94-V0.

Principle of use

- For voltage measurements, a current proportional to the measured voltage must be passed through an external resistor R_1 which is selected by the user and installed in series with the primary circuit of the transducer.

Advantages

- Excellent accuracy
- Very good linearity
- Low thermal drift
- Low response time
- High bandwidth
- High immunity to external interference
- Low disturbance in common mode.

Applications

- AC variable speed drives and servo motor drives
- Static converters for DC motor drives
- Battery supplied applications
- Uninterruptible Power Supplies (UPS)
- Power supplies for welding applications.

Application domain

- Industrial.

Voltage Transducer LV 25-P

Isolation characteristics

V_d	Rms voltage for AC insulation test, 50 Hz, 1 min	2.5 [1]	kV
$\hat{V}_w$	Impulse withstand voltage 1.2/50 µs	16	kV
		Min	
dCp	Creepage distance	19.5	mm
dCI	Clearance	19.5	mm
CTI	Comparative Tracking Index (group IIIa)	175	

Note: [1] Between primary and secondary.

Applications examples

According to EN 50178 and IEC 61010-1 standards and following conditions:

- Over voltage category OV 3
- Pollution degree PD2
- Non-uniform field

	EN 50178	**IEC 61010-1**
dCp, dCI, $\hat{V}_w$	Rated insulation voltage	Nominal voltage
Basic insulation	1600 V	1600 V
Reinforced insulation	800 V	800 V

Safety

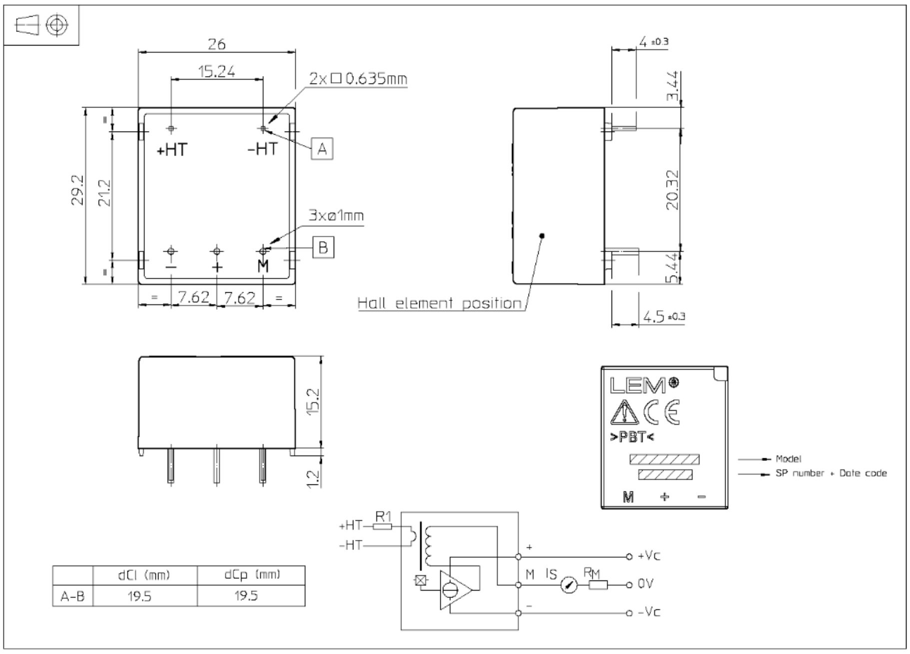
This transducer must be used in electric/electronic equipment with respect to applicable standards and safety requirements in accordance with the manufacturer's operating instructions.

Caution, risk of electrical shock

When operating the transducer, certain parts of the module can carry hazardous voltage (eg. primary busbar, power supply).
Ignoring this warning can lead to injury and/or cause serious damage.
This transducer is a build-in device, whose conducting parts must be inaccessible after installation.
A protective housing or additional shield could be used.
Main supply must be able to be disconnected.

LEM

Dimensions LV 25-P (in mm)



Mechanical characteristics

- General tolerance ± 0.2 mm
- Fastening & connection of primary 2 pins 0.635 × 0.635 mm
- Fastening & connection of secondary 3 pins Ø 1 mm
- Recommended PCB hole Ø 1.2 mm

Remarks

- I_S is positive when V_P is applied on terminal + HT.
- This is a standard model. For different versions (supply voltages, turns ratios, unidirectional measurements...), please contact us.

Instructions for use of the voltage transducer model LV 25-P

Primary resistor $\mathbf{R}_1$: the transducer's optimum accuracy is obtained at the nominal primary current. As far as possible, $\mathbf{R}_1$ should be calculated so that the nominal voltage to be measured corresponds to a primary current of 10 mA.

Example: Voltage to be measured V_{PN} = 250 V
a) $\mathbf{R}_1$ = 25 kΩ / 2.5 W, I_P = 10 mA Accuracy = ± 0.9 % of V_{PN} (@ T_A = + 25°C)
b) $\mathbf{R}_1$ = 50 kΩ / 1.25 W, I_P = 5 mA Accuracy = ± 1.5 % of V_{PN} (@ T_A = + 25°C)

Operating range (recommended): taking into account the resistance of the primary windings (which must remain low compared to $\mathbf{R}_1$, in order to keep thermal deviation as low as possible) and the isolation, this transducer is suitable for measuring nominal voltages from 10 to 500 V.

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